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CONTENTS

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The Canadian Entomologist

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Canadian Species of *Dioryctria* Zeller (Lepidoptera: Pyralidae)[1]

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Heinrich (1956) records four species of *Dioryctria* from Canada. Material in the Canadian National Collection includes eight species from Canada, two of them new. Also, one of the species recorded by Heinrich was in my opinion misidentified by him. In this paper I describe the new species, and give locality records and photographs of the other Canadian species, notes on taxonomy and host associations, and a key to the Canadian species.

Dioryctria rossi, new species

Figs. 1, 10

Dioryctria sp. Heinrich, 1956: 515, Fig. 870.

Male with a shallow basal antennal sinus containing modified scales, and with an aigrette-like maxillary palpus contained in a groove of the labial palpus. Head and labial palpus buff above, orange on sides, patagium orange with mesal edge buff; tegula orange; scales of notum buff; abdomen greyish brown above; body beneath greyish buff, with anterior surfaces of legs tinted with orange. Fore wing above pinkish orange, becoming yellowish along radius and in basal half of submedian area; a whitish streak along cubitus from base to end of cell; a diffuse whitish patch or pair of patches in cells M_3 and Cu_1 before postmedial line. Postmedial line white, somewhat diffuse, tending to be interrupted on veins; beginning behind costa, erect to M_1, bent outward to M_2 then gradually curved inward to Cu_2, thence erect, ending at anal fold; preceded by an obscure dark terminal shade; fringe buff with a whitish line in base, followed by a darker one. Hind wing light translucent fuscous, with veins and a marginal line darker; fringe whitish with a dark line in basal third. Under side nearly uniform grey; fore wing with obscure yellow lines on R and Cu, a weak pale discocellular bar, and a very obscure dark postmedial shade; hind wing as above. Expanse 24 to 30 mm.

Male genitalia. Uncus elongate; valve broad, apex broadly rounded, distal margin rounded or somewhat truncate, ventral angle with a fleshy flap, sacculus bearing a dorsal setose process; penis broadly cylindrical, containing about 25 straight, spine-like cornuti in a distal group.

Female genitalia. Bursa elongate, with a small sclerite in ductus just anterior to ostium, remainder of ductus sclerotized, followed by an expansion of anterior end of bursa on the left side, then a spinulose zone and a constriction, followed on the left by the broad opening of the ductus seminalis, remainder of bursa sac-like, bearing a spinulose zone on each side. Heinrich's Fig. 870 is an excellent representation.

Holotype, male, Nahun, B.C., reared from *Pinus ponderosa* Dougl., emerged July 12, 1952, Forest Insect Survey No. B.C. 52-237B. Allotype, female, Chief Joseph Mt., Joseph, Ore., Aug. 28, 1950, John L. and Grace H. Sperry. Paratypes: one male, Nahun, B.C., emerged July 15, 1952, reared from *Pinus ponderosa* Dougl.; one male, Leavenworth, Chelan Co., Wash., July 3, 1949; one female, Chief Joseph Mt., Joseph, Ore., Aug. 13, 1950, John L. and Grace H. Sperry; one

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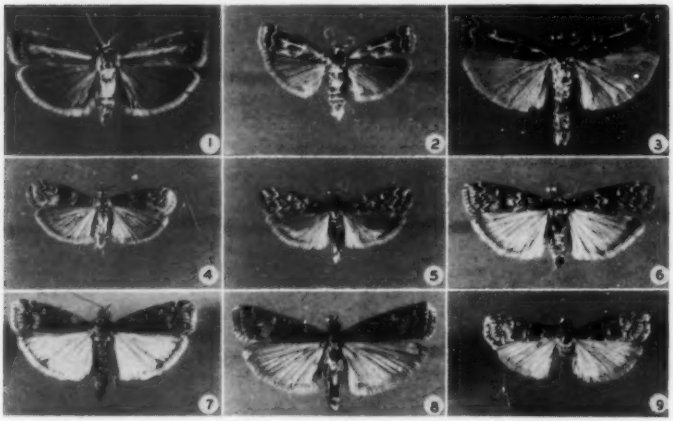


Figs. 1-9. *Dioryctria* spp.: 1, *D. rossi*, ♀; 2, *D. disclusa*, ♂; 3, *D. auranticella*, ♂; 4, *D. pseudotsugella*, ♂; 5, *D. reniculella*, ♂; 6, *D. abietivorella*, ♂; 7, *D. zimmermani*, ♂; 8, *D. cambiicola*, ♂; 9, *D. ponderosella*, ♂.

male, Estes Park, Colo., July 24, 1936, John L. and Grace H. Sperry; one female, Frijoles Canyon, N.M., July 30, 1942, L. A. Thomas. Type No. 6512, C.N.C.

The species is easily distinguished from *D. disclusa* Heinrich and *D. auranticella* (Grote) by the absence of the antemedial line of the fore wing and by the strikingly different male and female genitalia. I take pleasure in dedicating the species to Dr. D. A. Ross, Forest Insect Laboratory, Vernon, B.C., who first brought it to my attention. Heinrich gives an excellent figure of the female genitalia, with the caption "*Dioryctria* sp., a probable hybrid of *auranticella* and *erythropasa*."

Dioryctria disclusa Heinrich

Fig. 2

Dioryctria auranticella, of authors, in part, not Dyar, erroneous determination.
Dioryctria disclusa Heinrich, in Farrier and Tauber, 1953: 495.

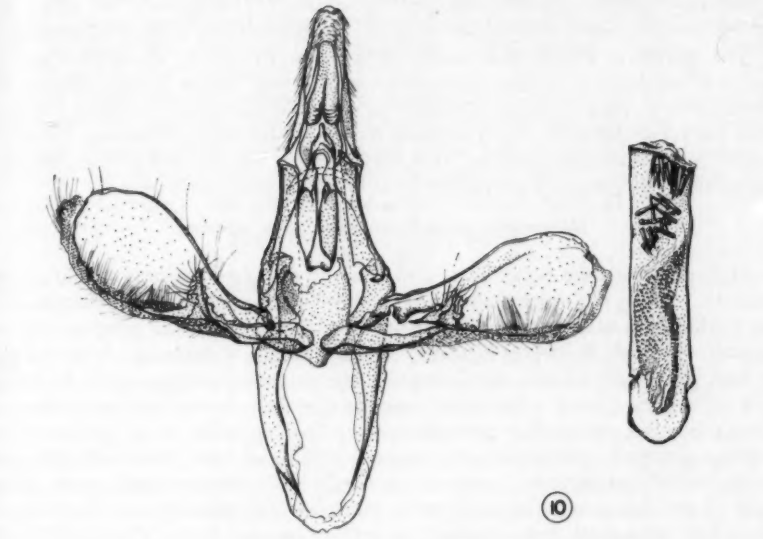
This species, formerly confused with *D. auranticella* (Grote), is recorded by Heinrich from a number of localities in the triangle from North Carolina to Massachusetts and Iowa. *D. auranticella* is common in southern Ontario, where the larva feeds in the cones of jack pine, red pine and Scots pine. The species has also been found in New Brunswick and suitable collecting methods would probably reveal its presence in other parts of Eastern Canada. The following specific locality records are available:—*New Brunswick*: Upsalquitch; *Ontario*: Constance Bay; Grand Bend; Mississagi Forest Reserve; Bewdley; Midhurst, Camp Borden; Brentwood; Angus; Chalk River; Williamsford.

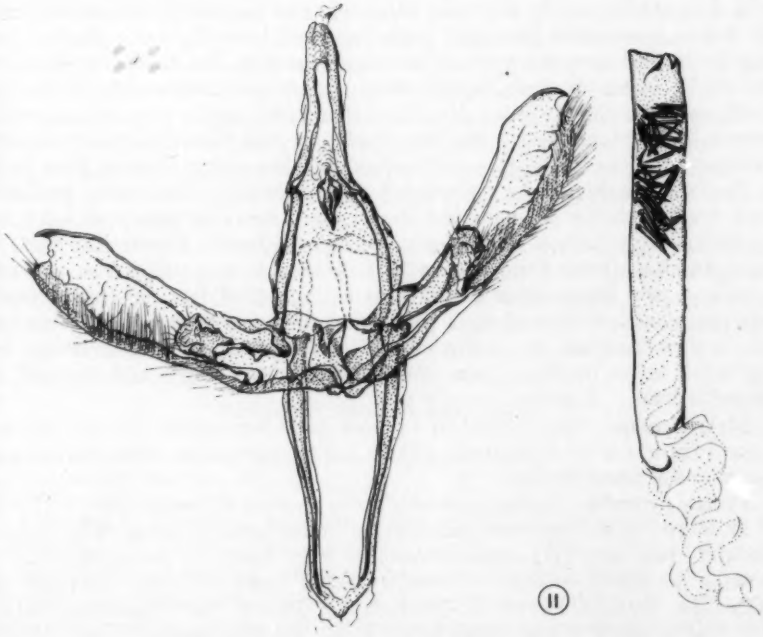
The larva bores in the cones of certain species of pine. In Canada it has been recorded from Scots pine, jack pine and red pine. An account of D. *disclusa* as it affects red pine in Canada is given by Lyons (1957, 1957a). Farrier and Tauber (1953) describe the biology of *D. disclusa* and Iowa, where it feeds on pitch pine, as well as on the species listed above.

Dioryctria auranticella (Grote)

Fig. 3

Nephopteryx auranticella Grote, 1883: 57.
Dioryctria miniatella Ragonot, 1887: 4.
Dioryctria auranticella, Hulst, 1890: 134.
Dioryctria xanthoenobares Dyar, 1911: 81.





Figs. 10, 11. ♂ genitalia of *Diorcytria* spp.: 10, *D. rossi*; 11, *D. pseudotsugella*.

This western species is closely similar in appearance to *D. disclusa* Heinrich, which has been confused with it in the past. The present species is larger, and has the maxillary palpus aigrette-like, not squamous. The species has often been referred to under the synonymous name *D. xanthoenobares* (not *xanthaenobares*).

The species is widely distributed in the western U.S.A. Heinrich records it from two localities in British Columbia: Kaslo, and Trout Creek, Ibapah Mts. I am not able to find the second locality in available gazetteers. There is material before me from the following Canadian localities: – *British Columbia*: Penticton; Martin Creek; Westbank; Nahun; Winfield; Lytton; Nicola; and Orama Mountain. Most of these specimens were reared from cones of ponderosa pine.

***Dioryctria pseudotsugella*, new species**

Figs. 4, 11

Male antenna with weak sinus and zone of modified scales; maxillary palpus squamous. Head and thorax above dark bluish grey with light-grey scales intermixed; abdomen above brownish grey, with blackish dorsal patches on most segments; anal tuft light greyish buff. Body beneath of varying shades of grey; legs dark grey with whitish distal rings on tibiae and tarsal segments. Fore wing above light grey dusted with black, especially before postmedial line, below cell, and just beyond postmedial line; antemedial line preceded in its posterior two-thirds by a rather conspicuous dull orange-buff patch, the line itself light grey, narrow, sometimes obscure, bordered outwardly by a narrow black shade; general course of the line somewhat oblique outward, an outward angle on R, an inward one on Cu_1, an outward one on Cu_2, an inward one on 2nd A, the lower limb at an angle of 45 degrees to inner margin; discocellular spot light grey, small and often hardly longer than wide; bordered inwardly and outwardly by inconspicuous dark shades; postmedial line light grey, bordered inwardly by a distinct black linear shade, and outwardly by an indistinct one; the line oblique inward from costa to M_1, there strongly angled, then oblique outward to M_2, there again strongly angled, oblique inward to Cu_2, there once again angled, and oblique outward to inner margin; a distinct black marginal line, sometimes minutely interrupted at veins; fringe grey, with a pale basal line and two darker lines farther out, the latter tending to be interrupted opposite veins. Hind wing pale translucent fuscous, darker on veins and at margin; traces of a pale postmedial band near costa; fringe whitish, with a grey line in basal third. Under side grey, fore wing somewhat darker than hind wing; fore wing with a pale streak on middle of costa, a pale discocellular mark, a dark postmedial line, obscure except at costa, immediately followed by a pale costal fleck, an obscure pale subterminal shade, a dark terminal line, followed by a creamy line in base of fringe; hind wing much as on upper surface, but with a slightly longer and stronger pale postmedial band. Expanse 20 to 24 mm.

Male genitalia. Closely similar to those of *D. reniculella* (Grote), but with the outer margin of the valve more oblique and the apex more acute; the aedoeagus proportionally more slender.

Female genitalia. Indistinguishable from those of *D. reniculella*.

Holotype, male, and allotype, female, Seton Lake, Lillooet, B.C., July 26, 1926 and Aug. 12, 1933 respectively. A long series of paratypes from the following localities: – *British Columbia*: Seton Lake, Lillooet; Victoria; near Goldbridge; Squilax; mouth of Momich R.; Mount Ida; Peachland; McLure Ferry; Cache Creek; Upper Louis Creek Road; Vernon; Paxton Valley; Venables Valley; Barrière; Denman Island; Stump Lake; Vinsulla; Ashcroft; Soda Creek; Manette Lake Road; Macalister Station; Macalister Ferry; Dutch Dairy Log Road; Quesnel; Quesnel-Wells Road; 2.5 miles north of Jamieson Creek; Kersley; Otter

Bay Road; Five Mile Creek; Sicamous; Kimsquit; John Dean Pk.; Falls Creek; Ladysmith; Snass Creek Valley; N. Pender Island; Valdes Island; Oregon Jack Creek; Lavington Gulch; Pritchard; Pillar Lake; Lumby; Kitchener; Princeton; Merritt; Canal Flat; Knoutt Lake; Beachy Head; Boston Bar; Bella Coola; Twin Lakes; Pavillion Mt.; Kakanee Pk.; Bridesville. *Washington*: Tenino, Thurston Co. Type No. 6513, C.N.C.

This species closely resembles *D. reniculella* (Grote), but is distinguished superficially by the paler ground colour, the much less strongly contrasting transverse lines, and the stronger brown shade before the antemedial line. It appears to be primarily associated with Douglas fir, from which many of the paratypes were reared, but two specimens are recorded from *Abies* sp.

***Dioryctria reniculella* (Grote)**

Fig. 5

Pinipestis reniculella Grote, 1880: 67.
Dioryctria reniculella, Ragonot, 1893: 200.

This species is distinguished from *D. pseudotsugella* by the dark fore wing with strongly contrasting pale transverse lines and discocellular spot. It agrees with *D. pseudotsugella* and differs from the following species in the dark-grey hind wing with a rather conspicuous pale subterminal band.

Heinrich records the species from Cape Breton, N.S., St. Therèse Island, P.Q., Westree, Ont., Saskatchewan, and Seton Lake and Victoria, B.C. Actually the species occurs almost throughout the forested region of Canada. The following definite Canadian records are available: – *Newfoundland*: St. Georges; Goose Bay, Labrador; *Nova Scotia*: Cape Breton; Pleasant Bay, Inverness Co.; *Prince Edward Island*: Brackley Beach, Can. Nat. Park; *New Brunswick*: York Co.; Dinnen Settlement; Fredericton; Grand Falls; Third Lake, Madawaska Co.; Goose Lake, Restigouche Co.; *Quebec*: Forestville; Maniwaki; Le Gite, Laurentide Park; Montreal; Rowanton; *Ontario*: Ottawa; Metagama; Gogama; Westree; Guelph; Port Hope; Mississagi R.; Biscotasing; Mica Bay; Sandy Falls; *Manitoba*: Aweme; *Saskatchewan*: Sutherland; *British Columbia*: Seton Lake, Lillooet; Ottertail; Davie Lake; Barrière; Reid Lake; Pritchard; Clearwater; Mouse Mountain; Lower Hat Creek Road; Stanley; Lake Island; Terrace; Kitimat Arm; Shames River; Crotch Creek; Hanford Lake; Upper Fraser; *Northwest Territories*: Fort Norman; mouth of Liard River.

This species feeds mainly on spruce, boring in the cones, twigs and buds. I have examined specimens reared from white spruce, Sitka spruce, Engelmann spruce, balsam fir, amabilis fir, and Douglas fir. The last appears to be a regular food plant, but the present species is much less common than *D. pseudotsugella* on it. The larva and biology are described by MacKay (1943).

The genitalia of both sexes are figured by Heinrich.

***Dioryctria abietivorella* (Grote)**

Fig. 6

Dioryctria abietella of authors, in part, erroneous determination.
Pinipestis abietivorella Grote, 1878: 701.
Myelois elegantella Hulst, 1892: 59.

This American species has been synonymized by almost all authors with the Palaearctic *D. abietella* (Denis and Schiffermüller). Although the two species are certainly closely related, there is in my opinion little doubt that they are different. The European specimens I have examined differ in facies from American ones, being larger, with darker hind wings, and with more conspicuous pale markings and more diffuse transverse dark lines on the fore wing. There is, moreover, an apparently constant difference in the configuration of the male valve. Although this difference is small, it is greater than that separating *D. abietella* from

the sympatric *D. mutatella* Fuchs. The difference is in the apical portion of the valve, which in *D. abietivorella* consists of a pointed or very narrowly rounded process, bearing a ventral spine well before the apex, whereas in *D. abietella* the apex is rounded or truncate, bearing a spine at the ventral angle which exceeds the apex proper, and in *D. mutatella* the apex is truncate, bearing two spines of about equal length. So far as I know, *D. abietella* does not occur in North America, but it should be looked for. Heinrich records *D. abietivorella* (as *D. abietella*) from Dublin Shore, N.S. (not Labrador!), Montreal, P.Q., Lutherland, Sask., and Kaslo, B.C. The species probably occurs in all provinces of Canada. The following specific records are available:—*Newfoundland*: Gander; Humber District; Avalon Peninsula; Grand Falls; St. Barbe; *Nova Scotia*: White Point Beach, Queen's Co.; *New Brunswick*: Tabusintac River; Acadia Forest Station, Sunbury Co.; *Quebec*: Berthierville; Norway Bay; Kazubazua; Montreal; *Ontario*: Ottawa; Alexander; Hindon Hill; Alfred; Hudson; Stevens; Ignace; Longlac; Jellicoe; Keewatin; Angus; Hopetown; Sioux Lookout; Fort William; *Saskatchewan*: Indian Head; *Alberta*: Nordegg; *British Columbia*: Seton Lake, Lillooet; Shingle Creek Road, Keremeos; Shawnigan; Vancouver; Hulcar; Eneas Creek; Agassiz; Trinity Valley; Cowichan Lake; Okanagan Landing; Lulu Island; Campbell Lake; Piggot Creek; Corrigan Creek; China Creek.

Heinrich says that in the U.S.A. this species is found most often on pine; in Ontario spruce seems to be the favoured host, according to records cited by Raizenne (1952); the majority of British Columbia specimens were reared from Douglas fir. However, the species feeds freely on pine in both east and west, and records are available from white pine, jack pine, Scots pine and lodgepole pine.

***Dioryctria zimmermani* (Grote)**

Fig. 7

Nephopteryx (Dioryctria) zimmermani Grote, 1877: 163.
Pinipestis zimmermani, Grote, 1878: 699.
Dioryctria zimmermani, Ragonot, 1889: 114.
Salebria delectella Hulst, 1895: 57.
Retinia austriana Cosens, 1906: 362.

This species and *D. cambiicola* (Dyar) differ from other Canadian species in having a ridge of raised black scales before the antemedial line of the fore wing. *D. zimmermani* is mainly eastern and has pale hind wings, *D. cambiicola* is western and has dark hind wings. The two forms do not differ otherwise, and Heinrich may be right in suggesting that they are conspecific. However, he listed them as distinct species and for the present I follow his arrangement.

Heinrich gives only one Canadian record: Toronto, Ont. I have examined material from the following Canadian localities:—*New Brunswick*: Flannagan Road, York Co.; *Quebec*: Fort Coulonge; Norway Bay; *Ontario*: Orr Lake; Locust Hill; Vineland; Hepworth; Angus; Camp Borden; Orono; Strathroy; *British Columbia*: Mabel Lake; Lillooet.

The two British Columbia specimens have less reddish-brown shading in the basal area than do either eastern specimens of *D. zimmermani* or western specimens identified as *D. cambiicola;* the hind wings are as pale as in any eastern specimens of *D. zimmermani.* The specimens recorded as *D. cambiicola* by Lyons (1957, 1957a) are best referred to *D. zimmermani.*

The species is recorded from the following hosts in Canada: spruce (three specimens reared from scar tissue at Fort Coulonge by J. M. Swaine), red pine, Scots pine, Mugho pine, Austrian pine, white pine, western white pine and ponderosa pine. The discontinuity in its range is probably apparent rather than real.

Dioryctria cambiicola (Dyar)

Fig. 8

Pinipestis cambiicola Dyar, 1914: 2.
Dioryctria cambiicola, Heinrich, 1956: 156.

As already noted, this species is similar in facies, structure and habits to the preceding, differing mainly in the dark colour of the hind wing.

Heinrich records the species from several western states, but not from Canada. Specimens are before me from Westbank and Skaha Lake, B.C., reared from yellow pine and ponderosa pine.

Dioryctria ponderosae Dyar

Fig. 9

Dioryctria ponderosae Dyar, 1914: 2.

In addition to the eight species listed above, *D. ponderosae* has been recorded from Canada (Bowman, 1951). Canadian specimens I have seen under this name are misidentified specimens of *D. abietella*, but the species is known from southern Montana (Bozeman and Lame Deer), and it is not unlikely that it occurs in Alberta and British Columbia. The adult resembles *D. zimmermani* in maculation, but has shorter, relatively broader wings, lacks brown tints in the basal area and has only a very weak raised band before the antemedial line. It differs from *D. abietella* in having the middle part of the postmedial line smooth, not dentate. The genitalia, figured by Heinrich, indicate relationship to *D. zimmermani*. The larva bores in the cambium of ponderosa pine.

Key to Species

1. Fore wing orange 2
   Fore wing grey 4
2. Fore wing with distinct pale antemedial band 3
   Fore wing without distinct antemedial band ..... *rossi*
3. Maxillary palpus of male squamous; eastern ..... *disclusa*
   Maxillary palpus of male aigrette-like; western ..... *auranticella*
4. Fore wing with a band of raised black scales before antemedial line 5
   Fore wing without such a band 7
5. Band of raised scales weak; fore wing relatively broad, medium grey, not suffused with black beyond antemedial line; no brown shade in basal area; discocellular spot contrastingly pale; hind wing light grey ..... *ponderosae*
   Band of raised scales strong; fore wing relatively narrow, dark grey, heavily suffused with black beyond antemedial line; usually a conspicuous brown shade in basal area; discocellular spot inconspicuous 6
6. Hind wing light grey ..... *zimmermani*
   Hind wing infuscated ..... *cambiicola*
7. Postmedial line of fore wing not dentate between M_2 and Cu_2 ..... *ponderosae*
   Postmedial line of fore wing obviously dentate between M_2 and Cu_2 8
8. Hind wing whitish grey, pale subterminal band lacking or scarcely evident; pale elements of transverse bands of fore wing inconspicuous; penis with a single stout spine basad of the rather few and large spines of the anterior cluster ..... *abietivorella*
   Hind wing usually weakly infuscated, pale subterminal band usually obvious; pale elements of transverse bands of fore wing conspicuous or a conspicuous pinkish-brown shade before antemedial line; penis without a single stout spine basad of the rather numerous and small spines of the anterior cluster 9
9. Fore wing medium grey; pale elements of transverse bands of fore wing moderately contrasting; a conspicuous pinkish-brown shade before antemedial line; western; larva on Douglas fir ..... *pseudotsugella*
   Fore wing dark grey; pale elements of transverse bands of fore wing conspicuous and contrasting; pinkish-brown shade before antemedial line usually inconspicuous; transcontinental; larva on various conifers ..... *reniculella*

Summary

Eight species of *Dioryctria* occurring in Canada and a ninth likely to occur in Canada are listed. Of these, two are described as new, one is distinguished

from an Old-World species with which it had previously been confused, and two others were not listed from Canada in Heinrich's revision. The species are figured, their Canadian localities and host-plants are listed, and a key to adults is given.

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Rearing Black Flies in the Laboratory (Diptera: Simuliidae)[1]

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The culture of black flies in the laboratory has been investigated by a number of workers in recent years. Attempts to establish continuous colonies failed, but adults were reared from eggs or first-instar larvae of *Simulium aureum* Fries and *S. erythrocephalum* (Deg.) by Puri (1925), of *S. ornatum* Meig. by Smart (1934), of *S. trivittatum* Mall., *S. callidum* (D. & S.), *S. metallicum* Bell., and *Gigantodax wrighti* V., M., and D. by Vargas (1945) and Dalmat (1955), of *S. ornatipes* Skuse by Mackerras and Mackerras (1948), and of *S. salopiense* Edw. by Zivkovic (1951). Flowing water for the larvae was provided by bubbling compressed air through the water or by using a natural stream. Food consisted of algae, skim milk powder, powdered yeast, or "ground purina".

Since 1950, at Saskatoon, more than 310 rearing tests were conducted with some 80,000 first-instar larvae or eggs of eight species of black flies. This is a report on three methods of circulating water in laboratory aquaria as well as on foods, population densities, and other factors affecting the survival and rate of growth of larvae. Data on optimum physical conditions for the larvae are presented although these are not final because of a lack of temperature control in most tests.

Means of Circulating Water

A rate of flow of about 0.2 to four feet per second, with a minimum of turbulence, is necessary to duplicate stream velocities in the natural habitats of local species of black-fly larvae.

Compressed Air

The use of compressed air reported by Puri (1925) and Smart (1934) was variously modified in attempts to increase the survival of larvae and to facilitate observations. Aquaria varying in capacity from 10 ml. to 5,000 ml. and in shape from round test tubes to square battery jars were tested (Figs. 1 to 3). Compressed air at five to 20 pounds per square inch was forced through a jar containing wood shavings to trap foreign particles before they reached the manifold outlets, and was finally released into the bottom of each aquarium through a finely drawn glass tip or through a fritted glass plug (Figs. 1 and 3). The latter was favoured as it produced relatively little concussion and noise. The stream of air bubbles was allowed to rise, either through a chimney or under a slanted glass plate, so that a continuous circulation of water at speeds of up to 1.4 feet per second was created in the aquarium. Clean surfaces were essential; the larvae did not readily attach to surfaces that were covered with slime, food, or silt. Larvae and pupae were generally found where the flow was strongest, and were often attached to the air-stream outlet. Emerging adults were collected in a cage placed over the top of each aquarium.

The advantages of this system are the variations possible in the number, size, and shape of aquaria that can be used, and the ease with which emerging adults can be collected. The number of aquaria that can be used depends, of course, on the capacity of the air compressor. The main disadvantage is that the maximum rate of flow, about 1.4 feet per second, is inadequate for larvae of certain species.

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Platform Shaker

To provide circulation of water in aquaria without using compressed air, a platform shaker was devised. After considerable experimentation with three different models, a machine capable of holding about seventy 450-ml. aquaria was built (Figs. 4 and 5). This machine was powered by an electric motor of 0.5 h.p. and 1,725 r.p.m., equipped with a thermal overload switch and mounted on a spring-loaded plate to provide for automatic belt-tension adjustment. A 3.25-inch, variable-speed pulley on the motor drove, by means of a V-belt, a nine-inch pulley mounted on a vertical shaft. At the other end of this shaft a two-inch pulley drove, by means of a second V-belt, a 12-inch pulley mounted on a second shaft; at the opposite end of the second shaft was a cam shaft, offset by 0.75 inches. This cam shaft was attached to the centre of the underside of a horizontal platform, and caused it to shake in a circular motion at 80 to 120 times per minute, depending upon the size of the variable-speed pulley. The platform was supported at each of its four corners by a 10-inch leg of strong rubber tubing. Round, glass aquaria with lids were clamped upon the platform. The circular motion of the platform induced a flow of the water, the rate of flow depending upon the size of the aquarium, the depth of water, and the number of revolutions per minute. With 200 ml. of water in an aquarium 3.5 inches in diameter, and the table shaking in a 1.5-inch circle at 100 r.p.m., the maximum induced rate of flow was about 0.3 feet per second. This comparatively slow rate of circulation limited the use of this machine to the rearing of those species of larvae that normally inhabit slowly flowing streams.

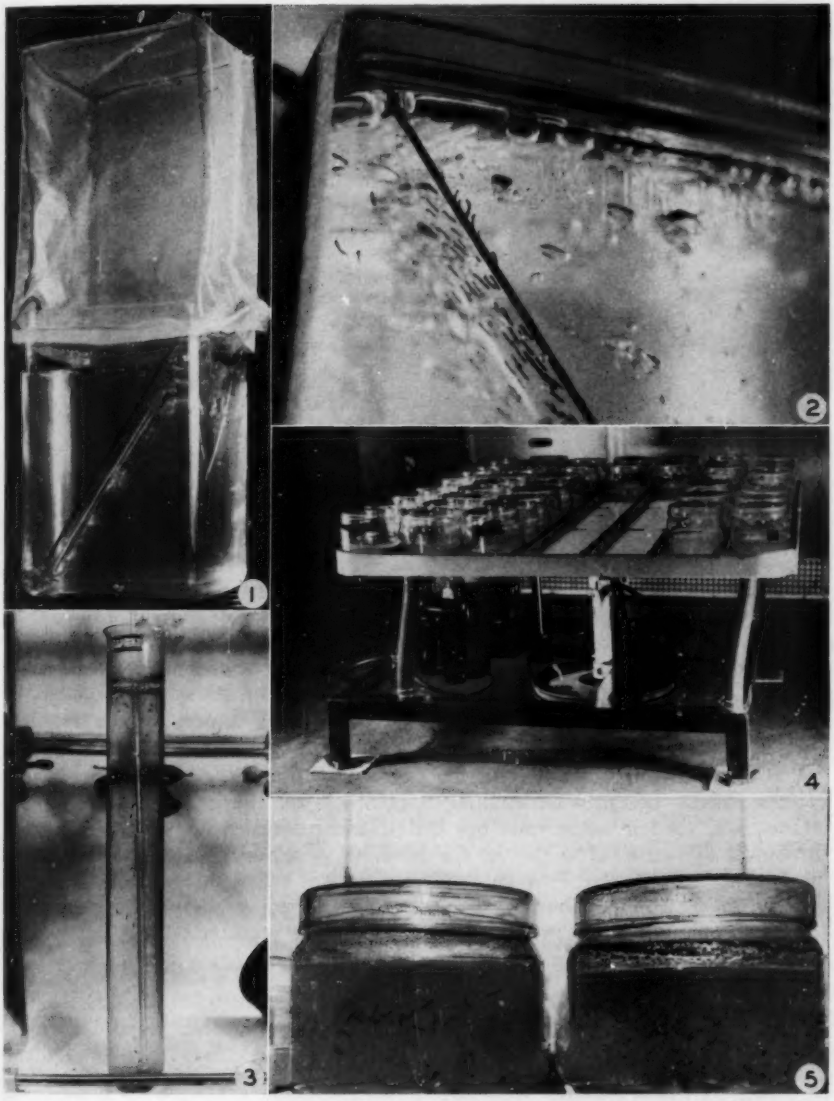
Emerged adults remained on the water surface or clung to the glass, and many remained alive and in good condition for at least 24 hours. An emergence cage with a cloth top on each aquarium did not appear to increase the longevity of the adults, and was abandoned in favour of a glass lid that prevented evaporation and kept out air-borne contamination.

Rotating Platform

A third type of machine was devised to provide a relatively rapid rate of water-flow in aquaria. This machine (Fig. 6) consisted of 12 rotating platforms. Upon each platform a round aquarium was tightly clamped. As the aquarium rotated, the water moved with it. A stationary rod (Fig. 7), fixed above the centre of each aquarium, projected downwards into the water. Vegetation or horizontal plates were attached to this rod and held stationary while the water flowed past. The use of horizontal plates was favoured because they created relatively little obstruction and turbulence in the flowing water. They were constructed of transparent plastic, which permitted an unobstructed view of the contents of the aquarium. Larvae attached mainly to the stationary plates (Fig. 8) or other obstructions, but a small percentage attached to the aquarium walls.

A cover over the top of each aquarium kept out dust and prevented evaporation. Adults emerging from pupae in the water could not cling to the revolving walls and cover. Hence, when live adults were required the cover was removed; the emerged adults immediately flew to the windows, where they were easily collected.

This machine was powered by a motor of 0.5 h.p. and 1,725 r.p.m. A 2.5-inch V-belt pulley on the motor drove a five-inch pulley mounted on the end of a shaft. A three-inch pulley on the other end of this shaft drove a seven-inch pulley on the end of a second, four-foot shaft. Each of twelve 1.5-inch



Figs. 1-5. 1, in this aquarium water is circulated by compressed air escaping from a glass tube drawn to a fine point and rising under a slanted glass plate; note cage for retention of emerging adults; 2, larvae of *Simulium venustum* attached to a glass plate in water circulated by compressed air; 3, larvae and pupae of *S. venustum* in water circulated by air bubbles rising from a fritted glass plug; 4, a platform shaker used to create flow of water in small aquaria; 5, larvae and pupae of *S. vittatum* attached to walls of aquarium on a platform shaker.

pulleys mounted along this shaft drove a three-inch pulley mounted on the underside of a rotating platform. With this combination of pulleys, each aquarium rotated at approximately 180 r.p.m., and carried the water over the outer edges of the plates at speeds of up to 4.5 feet per second.

Water

Water was obtained from several sources, depending upon the requirements for each series of tests. Tap water or distilled tap water, allowed to stand in open vessels for one or two days, was suitable for most of the tests. The tap water was practically free of suspended and dissolved organic and inorganic material, but contained varying amounts of chlorine and traces of fluorine as required by the municipal health department. Water from a 3,000-gallon greenhouse aquarium, rich in unicellular algae, or water from streams and rivers, strained to remove aquatic insects, was used in those tests where the exact amount of food in the water was not required to be known.

Food

Black-fly larvae apparently feed mainly on particles of food suspended in flowing water; they are also reported (Puri, 1925; Peterson, 1956) to scrape food from the substratum with the mouth parts. In laboratory tests Puri (1925), Bradt (1932), and Smart (1934) kept larvae alive in water rich in algae. Bradt also used skim-milk powder and powdered yeast, and Vargas (1945) used different types of "ground purina". Rubtzov (1956) stated that the maintenance of larvae in the laboratory was difficult but could be accomplished in water rich in "micro-organisms".

In many of the Saskatoon tests a suspension of live yeast cells (dehydrated baker's yeast) alone provided the nutrient for the development of adults from eggs. This was readily available and easily stored and weighed, and the pellets rapidly disintegrated into individual yeast cells when placed in water. Precise amounts of yeast were provided, for whole series of tests, by dispersing a weighed quantity in a known volume of water and dispensing the required quantity through a burette.

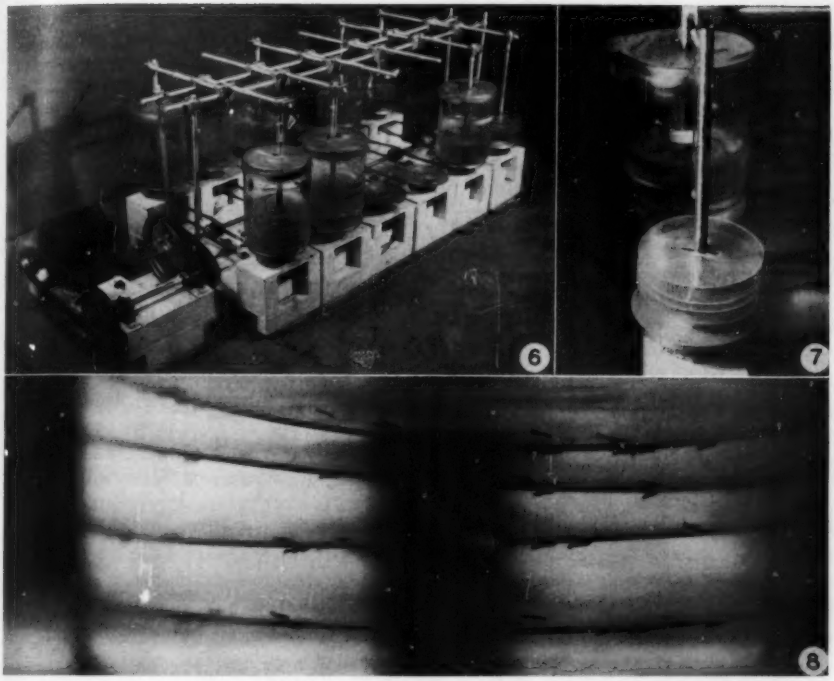
Pablum (Mead Johnson and Co., Belleville, Canada), a dehydrated, precooked, mixed cereal with vitamin B complex and mineral supplements for infants, was used in some tests but had to be ground in a mortar and sieved through a 150-mesh screen before the partioles were small enough to be readily ingested by the larvae. As the Pablum suspension could not be dispensed satisfactorily through a burette, it was necessary to weigh out individual lots for each aquarium when precise feeding rates were required.

A laboratory-cultured unicellular alga, *Leuvenia natans* Gard., was used in a few tests.

Tests on rearing larvae in a nutrient solution that contained no particles were largely unsuccessful. Larvae survived for only a few days and developed only to the second instar in sterile solutions of yeast extract or nutrient broth. In a few of the non-sterile solutions, a small number of adults of *S. vittatum* were produced. The larvae in these instances presumably fed on bacteria rather than the solutions.

Temperature

Aquaria served by compressed air were occasionally placed in a water bath at a constant temperature but those served by the revolving platform and the platform shaker were subject to air-temperature fluctuations within the laboratory. Observations indicated that temperature is a critical factor in the



Figs. 6-8. 6, a rotating platform machine used to create rapid flow of water in aquaria; 7, a stationary rod carrying four horizontal plates in position above a rotating platform; the aquarium has been removed to show these details; 8, larvae of *S. arcticum* attached to plates in an aquarium on a rotating platform.

survival and development of black-fly larvae. Larvae of *S. arcticum* developed to maturity only when water temperatures remained below 70° F., whereas larvae of *S. vittatum* survived temperatures as high as 92° F. Because of a lack of temperature control in most tests, definite conclusions could not be reached concerning effects of other variables, such as food and population density, on the survival and rate of growth of larvae.

Handling of First-instar Larvae

In critical tests where the age and density of the initial colonies were controlled, first-instar larvae were used. The larvae were counted readily with the aid of a finely tapered glass pipette. A rubber bulb provided suction. Careful manipulation of the bulb was necessary to avoid damaging the larvae in the tip of the pipette. In sorting larvae, use was made of the fact that they are positively phototactic in still water. For example, if all of the debris, larvae, and unhatched eggs in a hatching dish were placed at one side of the dish, in a few moments the active, healthy larvae would move out of the debris towards the light, where they could be picked up. A low-power, wide-field binocular microscope was necessary for accurate counting. First-instar larvae were readily distinguished from the later instars by the presence of the egg-burster, a dark, prominent knob on the dorsal surface of the head capsule.

Species

Of 25 species native to the prairie region of Western Canada, the adults of eight were reared from eggs or first-instar larvae. The eggs or larvae were collected within 100 miles of the laboratory at Saskatoon.

Cnephia dacotensis (D. & S.)

C. dacotensis mates on the ground rather than in swarms as do members of the genus *Simulium*. Also, unlike those of most other black flies, the eggs are laid within a few hours after emergence; a blood meal is not required for the maturation of the ova. In the laboratory, mating and oviposition occurred at about 70° F. in closed containers. A high density of adults promoted mating but isolation increased the average length of life and number of eggs produced.

About 100 adults were reared from eggs laid in the laboratory by females collected in flight or from eggs collected from streams. Larvae were reared in tap or river water circulated at 0.3 to 1.4 feet per second by the platform shaker or compressed air. No attempt was made to use a more rapid rate of flow although larvae were found in streams flowing as fast as three feet per second. In the aquaria there were about two ml. of water for each larva, and about 15 p.p.m. of bakers' yeast were added daily. Water temperatures varied from 58 to 87° F. and averaged about 74° F. Pupae were produced in as few as 20 days and adults in 30 days after the eggs hatched.

Although the life-cycle was completed in the laboratory, low viability of eggs and a lengthy egg stage and hatching period prevented the establishment of a continuous colony. Eggs laid in the laboratory had to be kept for five to seven months at natural stream temperatures before hatching commenced. Hatching extended over a two-month period and only one percent of the eggs eventually hatched. One to two months of refrigeration at 32 to 33° F. to simulate overwintering conditions failed to accelerate or increase the hatch. Bradley (1935) also reported a lengthy egg stage for *C. pecuaria* (Riley).

Simulium arcticum Mall.

S. arcticum is the most important black-fly pest in the Prairie Provinces, and an annual program of control is required to prevent outbreaks and livestock fatalities. Here it apparently has only one generation in a year, the larvae and adults being abundant only during May and June. The adults mate in swarms, and a blood meal is required for the maturation of the ova (Cameron, 1922). Larvae develop abundantly in the rapidly flowing water of the Saskatchewan River. Cameron obtained adults of *S. arcticum* (*S. simile* Mall.) from larvae, presumably mature, kept in tap water flowing down a plate held at an angle of 45°.

Of the eight species tested, *S. arcticum* was the most difficult to rear from first-instar larvae to adults. The larvae developed to the third instar in water flowing at 0.3 to 1.4 feet per second, but it was only in water flowing at 4.5 feet per second that even a few pupae and adults were produced. Furthermore, the larvae were relatively intolerant to above-normal temperatures. In their natural habitats older larvae were found in abundance only at temperatures of 57 to 64° F. though young larvae were found in water at less than 40° F. In the laboratory, temperatures ranged from 60 to 89° F. and larvae survived only at the lower end of this range. Only 23 adults developed from more than 17,000 first-instar larvae. In the most successful test, 20 adults were reared from 750 first-instar larvae in 1,500 ml. of muddy river water. Dehydrated bakers' yeast was added to the water at 7.5 p.p.m. daily.

S. aureum Fries

This species is relatively rare in the Canadian prairie region. The immature stages usually occur in the smallest streams but occasionally in rivers, in water flowing at 0.2 to 2.5 feet per second. Puri (1925) reared adults from eggs and stated that the larval stage lasted four to five weeks.

A few eggs, dredged from a stream in September, 1957, and kept at 34° F. for 15 weeks, were placed in tap water in three aquaria and provided with 30 p.p.m. of yeast daily. The water in one aquarium was circulated at about one foot per second by compressed air and in the other two at 0.3 feet per second by the platform shaker. In the aquaria served by the platform shaker, some eggs hatched but no larvae survived to the pupal stage. In the aquarium served by compressed air seven adults emerged, along with several adults of *S. venustum*. This aquarium contained 1,300 ml. of tap water; 30 p.p.m. of dehydrated bakers' yeast was added daily. Water temperatures ranged from 70 to 74° F. Adult emergence began 17 days after the eggs were introduced. The shortest larval period was estimated to be about 14 days.

S. decorum Walk.

S. decorum is a multi-voltine species that overwinters in the egg stage; mating occurs on the ground and oviposition occurs both in flight and on the ground; a blood meal is apparently not always necessary for the maturation of ova (Davies and Peterson, 1956). These features suggested that a continuous colony of this species might be established in the laboratory with relative ease.

S. decorum is not abundant in the Canadian prairie region, but about 300 eggs were collected from a stream in 1955. An unknown number hatched, and the larvae were reared in river water circulated at 0.3 feet per second in aquaria on the platform shaker. Only three adults emerged, but this indicates that it is possible to rear these larvae in laboratory aquaria. Bakers' yeast was added to the water at about 15 p.p.m. daily. Water temperatures ranged from 58 to 79° F. with an average of 72° F. The first pupa was formed 16 days after the eggs were placed in the aquaria and the first adult emerged four days later. Mating or oviposition did not occur.

S. luggeri N. & M.

Observations indicated that *S. luggeri* also has several generations in a summer and overwinters in the egg stage in the Canadian prairie region. Nothing is known of the mating habits. It commonly attacks large animals for blood.

About 500 eggs were collected from a stream in 1955 and a smaller number in 1957, and larvae were reared in the laboratory in water circulated at about 0.3 feet per second by the platform shaker and in water circulated at about one foot per second by compressed air. In streams, larvae were found in abundance only where the rate of flow was 0.5 to two feet per second. More than 60 adults emerged in the laboratory. The shortest periods of development from first-instar larvae to pupae and adults respectively were 21 and 25 days. Both river and tap water were used in these tests, and bakers' yeast was added at 15 to 30 p.p.m. daily. Water temperatures ranged from 58 to 79° F. with an average of 72° F.

S. meridionale Riley

Larvae of *S. meridionale*, like those of *S. arcticum*, are found in relatively fast-flowing water. In streams, larvae were abundant only where the rate of flow ranged from 1.5 to three feet per second. It is a blood-sucking species, but little is known of its life-cycle or habits.

In the laboratory two adults and a small number of pupae were reared from first-instar larvae in river and tap water circulated at 4.5 feet per second by the revolving platform and from eggs in water circulated at about one foot per second by compressed air. The first pupa was observed 14 days after the introduction of the larvae and the first adult five days later. There was one larva for each two ml. of water, and 7.5 to 60 p.p.m. of bakers' yeast was added daily. Water temperatures varied from 68 to 89° F. with an average of 75° F. The larvae were collected along with those of *S. arcticum* from rapids in the Saskatchewan River, and the eggs were dredged from the Battle River.

S. venustum Say

This is one of the most abundant of the bloodsucking black flies in the Canadian prairie region. It is a multi-voltine species and overwinters in the egg stage. Tests showed that the eggs remain viable for at least a year when stored at 32 to 33° F., a feature that is useful in laboratory investigations. However, mating apparently occurs only during flight in swarms, and a blood meal is required before the ova will mature, indicating that the establishment of a continuous laboratory colony would be difficult. In captivity, adults could not be induced to swarm but spent their time crawling vigorously on the netting, while attempting to escape to the light.

Eggs of *S. venustum* were plentiful in streams near the laboratory and more than 95 tests starting with more than 38,000 eggs or first-instar larvae were carried out; adults were reared from these under a wide variety of conditions. Larvae were successfully reared in tap, distilled, and river water, flowing at rates of 0.3 to 4.5 feet per second and with densities of 0.05 to 0.5 larvae per ml. of water; temperatures ranged from 68° to 89° F., and the food consisted of dehydrated yeast, Pablum, or algae supplied at rates of one to 1,000 p.p.m. daily. The fastest development and greatest survival occurred in aquaria containing tap water circulated by compressed air at a maximum rate of flow of about 1.4 feet per second, the initial density being about 0.1 first-instar larvae per ml. of water and Pablum being provided daily at 15 p.p.m. Pupae were first observed eight days after the introduction of the larvae, and adults five days later; 16 per cent of the original colony survived to the adult stage.

Some of the tests with *S. venustum* were conducted during the winter with the aquaria in total darkness for 14 to 16 hours each day. In these tests unicellular green algae (*Leuvenia natans*) were added to the water. These aquaria produced relatively few adults, perhaps because of low diurnal water-oxygen tensions.

S. vittatum Zett.

This is the most widespread and at times the most abundant species of black fly in the region. Observations indicated that the immature stages could tolerate a wider variety of stream conditions than could those of the other seven species except possibly *S. venustum*. For instance, larvae were found in streams with water temperatures of 32 to 88° F., with velocities of 0.2 to 3.4 feet per second and with salinities of up to 3,030 p.p.m. of dissolved solids. This species is one of the few in the region that overwinters as larvae rather than as eggs, and laboratory tests showed that the eggs do not survive for more than a few weeks when stored at 32 to 33° F. At higher temperatures the eggs hatch, so that rearing tests with this species were conducted only during the egg-laying season.

Emery (1913) kept the mature larvae alive for a few days in flowing tap

water and obtained adults 12 days after the larvae were collected from a stream. This was perhaps the earliest attempt to rear black-fly larvae in the laboratory.

More than 125 tests involving over 22,000 eggs or first-instar larvae of *S. vittatum* were conducted in the laboratory. Larvae were reared in the laboratory under a wide variety of conditions; the food consisted of daily offerings of one to 1,000 p.p.m. of dehydrated yeast, Pablum, or algae, the colonies averaged 0.03 to 4.0 larvae per ml. of distilled, tap, or river water, the temperatures ranged from 68 to 92° F. and the water velocities from 0.3 to 4.5 feet per second. Because most of the tests were carried out under irregularly varying temperatures, it is difficult to relate results to any particular environmental condition.

However, the greatest survival was obtained in an aquarium containing 0.06 first-instar larvae per ml. of tap water, on a platform shaker; 42 adults were reared from 100 larvae. Two parts per million of yeast were provided daily at the start of the test; this was increased to 15 p.p.m. daily as the larvae attained maturity.

The fastest growth occurred in an aquarium on a platform shaker containing 0.5 eggs per ml. of water, which was rich in algae and to which yeast was added at 16 p.p.m. daily. Pupation started on the eleventh day and adult emergence on the fourteenth.

Daily population changes in another colony, contained in five aquaria on a platform shaker are shown in Fig. 9. At the start of the test each aquarium contained 100 larvae and 200 ml. of aerated tap water. Yeast was added at 15 p.p.m. daily and increased progressively to 30, 60, and 120 p.p.m. daily as the larvae increased in size. Pupation began on the nineteenth day and adult emergence on the twenty-first. On the thirty-seventh day the last larva pupated and on the forty-first day the last adult emerged. The total mortality was 82 per cent, 67 per cent during the first instar, 11 per cent during the later instars and four per cent during the pupal stage. The loss of about two-thirds of the larvae during the first day of these tests may have been the result of poor technique or poor larval vitality or both; in certain other tests first-day losses were as low as ten per cent.

Establishment of a Laboratory Colony

The possibility of establishing a continuous colony of black flies was not fully investigated. An initial requirement is the development of methods of confinement under which adults will mate and feed. The adults of *Simulium* species normally mate in swarms and no one has induced the formation of a mating swarm in captivity. When confined in a cage, these black flies remain on

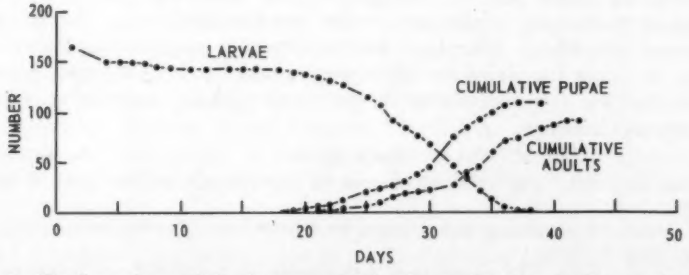


Fig. 9. Total numbers of *S. vittatum* surviving in rearing tests in five platform-shaker aquaria, each of which initially contained 100 first-instar larvae.

the walls, either resting or seeking to escape to the light. Also, black flies have seldom been induced to feed on blood in the laboratory although they readily consume water and sugar. *S. arcticum* and *S. griseum* Coq. females ingested some blood from a solid mixture of agar and beef blood; feeding was particularly active when the agar was warmer than the air. None of these black flies laid eggs, and none survived longer than five days.

Conditions suitable for oviposition were easily duplicated in the laboratory; gravid females of *S. arcticum*, *S. venustum*, *S. vittatum*, and *C. dacotensis*, collected from their natural habitats, oviposited on wet surfaces in cages.

Some of the characteristics of the life-cycle of *C. dacotensis* suggest that a continuous colony of this species might be established with relative ease. However, it will first be necessary to develop techniques that will overcome the slow embryological development and low viability of laboratory-stored eggs.

Summary

Methods and equipment are described for rearing adults of eight species of black flies from eggs or first-instar larvae in the laboratory. Compressed air, a platform shaker, and a rotating platform were used to circulate water in aquaria at speeds characteristic of the natural habitats of the species investigated. Speeds ranged from 0.3 to 4.5 feet per second.

Larvae of *Simulium venustum* Say and *S. vittatum* Zett. developed from the first instar to adults in a relatively wide range of laboratory environments, although greatest survival and growth of *S. venustum* occurred in water circulated by compressed air and *S. vittatum* was reared most successfully in aquaria on the platform shaker. Larvae of *S. arcticum* Mall. developed to maturity only in rapidly flowing water in aquaria on the rotating platform. Few eggs or larvae of *Cnephia dacotensis* (D. & S.), *S. aureum* Fries, *S. decorum* Walk., *S. luggeri* N. & M., and *S. meridionale* Riley were available but small numbers of each species were reared to the adult stage.

The differences in the rates of survival and growth of larvae in aquaria served by the three machines may have been due mainly to difference in water velocities. However, other factors such as density of the larvae, the amount and kind of food offered, temperature, and water source appeared important. Definite conclusions concerning the importance of these various factors could not be reached in these tests because of the lack of temperature control.

A continuous colony of black flies was not established. However the methods and equipment described should have considerable value in studies on life-cycles, behaviour, and control and for associating the adult and immature stages.

Acknowledgments

I wish to thank Mr. G. Burgess of the Saskatoon laboratory for his assistance in developing a platform shaker suitable for rearing the larvae, Mr. S. Cameron and Mr. I. Newsham for considerable technical assistance in the tests, Mr. R. Lowe for taking the photographs, and Dr. J. G. Rempel, University of Saskatchewan, for suggestions in the work and for translating a part of the article by Rubtzov.

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New Canadian Black Flies (Diptera: Simuliidae). II[1]

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Genus *Simulium* Latr.

Hagenomyia new subgenus

Large species; thoracic dorsum conspicuously trivittate; mesopleural membrane bare; basal section of radius bare; tibiae without bright niveous patches; fore tarsal segments not much dilated. Female: head and thorax thickly cinereous-pollinose; mouth parts adapted for biting; tarsal claws simple; posterior margin of seventh abdominal sternite with conspicuous fringe of long hairs; paraproct (anal lobe) with large, highly polished ventral prolongation; ovipositor lobes very widely separated. Male: style without apical tooth; ventral plate broadly cleft almost to base. Pupa: respiratory organ with nine uniformly radiating, somewhat inflated, rather short filaments; abdominal armature lacking on fifth to seventh tergites; cocoon fabric loosely reticulate, porous, with greatly elevated opening. Larva: exceptionally long and slender, evenly expanding posteriorly, seventh abdominal segment strongly bulbous ventrally; antenna six-segmented; submentum with eight to 11 hairs on each side.

Type species, *Simulium pictipes* Hagen, 1880.

Distribution: Eastern North America. In U.S.A., south to Georgia, west to Minnesota and Oklahoma. In Canada, north to latitude 55° in Quebec, west probably to the head of the Great Lakes. Type locality, Ausable River, New York.

Hagenomyia differs from all other Nearctic subgenera of *Simulium* in the deeply-cleft ventral plate of the male, in the conspicuous fringe of long hairs on

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the seventh abdominal sternite of the female, and in the wholly reticulate structure of the cocoon.

S. pictipes has been considered to be closely related to *Simulium* (*Neosimulium*) *vittatum* Zett. (Dyar and Shannon (1927), Rubtzov (1940), Nicholson and Mickel (1950)) but there are very marked differences in the genitalia of both sexes, in the structure of the pupal filaments and cocoon, and in several larval head characters as well as the general form of the larva. In addition, the larva of *pictipes* has a restricted habitat, being confined to the swiftest most turbulent waters near falls and gorges, whereas that of *vittatum* is exceptionally adaptable to varying stream conditions.

Hagenomyia appears to be closer to the western Nearctic and Neotropical subgenus *Hemicnetha* Enderlein (1934, type *H. paynei* Vargas) than to any species found in eastern North America. In the two subgenera, the species tend to be large with well-developed thoracic markings; the second antennal segment of the larva is subdivided, giving a total of six or more antennal segments; the submentum has eight to 11 marginal hairs; the anterior opening of the cocoon is greatly elevated above the substrate, and the pupa has eight to 11 (in *Hemicnetha* occasionally 15 to 17) somewhat inflated, rather short filaments. In addition, several species of *Hemicnetha* breed in very fast turbulent waters. On the other hand, marked genitalic differences as well as wide geographical separation serve to emphasize the distinctness of these two groups.

Simulium (Hagenomyia) longistylatum n.sp.

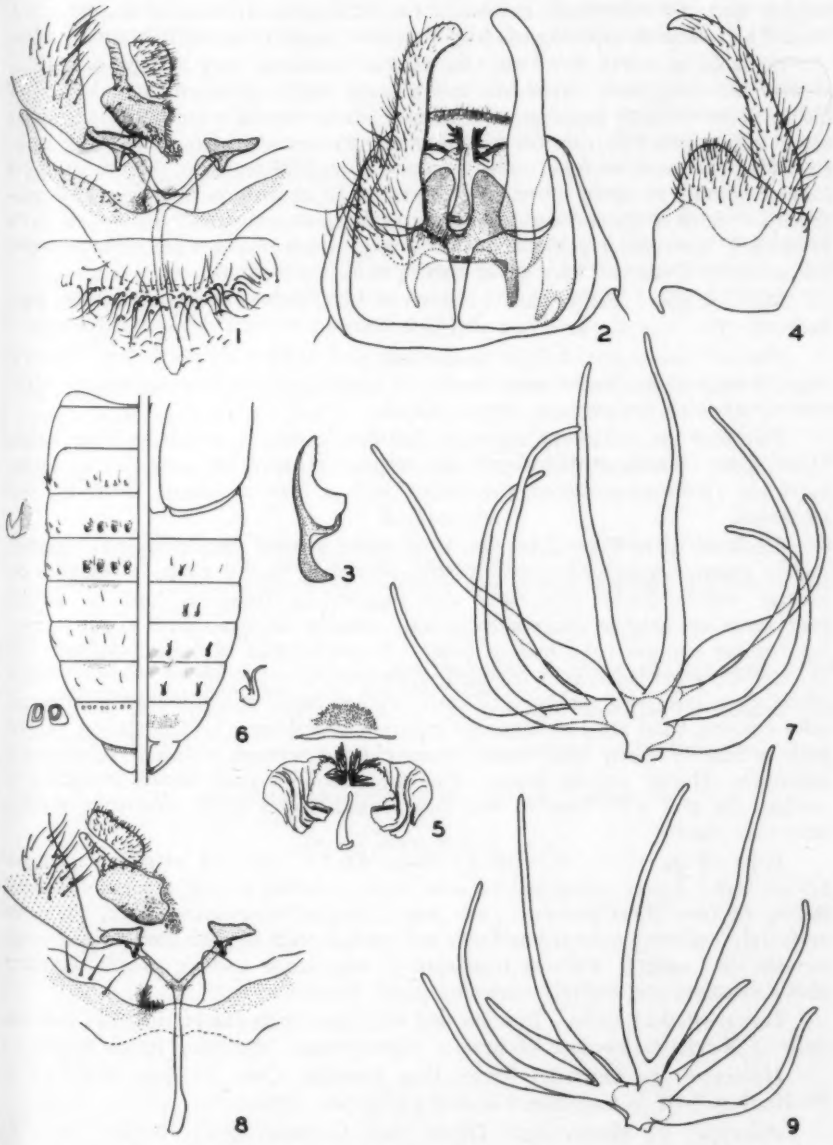
Simulium (subgen.?) n.sp. nr. *pictipes* Hgn. Shewell, 1957. Interim report on distributions of the black flies (Simuliidae) obtained in the Northern Insect Survey. *Canada Dept. Natl. Def., Def. Res. Bd. Envir. Prot. Tech. Rept. No.* 7, *Map* 47.

Large grey and black species with conspicuously trivittate thoracic dorsum, very similar to *pictipes* except in the genitalia and pupal respiratory filaments. Length of body 3.0-4.0 mm., of wing 3.5-4.5 mm.

Female.—Head black, thickly cinereous-pollinose. Frons at vertex 0.3 of head width, almost as wide as long, scarcely narrowed below; hairs pale, those bordering the eyes longer and black. Clypeus as broad as long, with pale decumbent hairs. Occipital hairs extensively black above, pale laterally and below; occipital fringe black. Antenna black with pale pubescence, basal two segments dark brown. Palpus black, with black hairs, third segment slightly enlarged. Mouth parts dark brown to black.

Thorax black, cinereous-pollinose; humerus sometimes dark brown. Mesonotum with three dark vittae, median one sublinear, each lateral one broader, sinuous, its anterior end expanded ovate at humeral depression, the expanded area bright niveous in oblique posterior view; on either side of median vitta and outside each lateral vitta a brown-pollinose area; vestiture rather sparse, short, decumbent, shining pale golden, longer and interspersed with proclinate black hairs posteriorly. Scutellum with decumbent pale hairs and long erect pile of both black and pale hairs. Pleural hair tufts white. Knob of haltere pale yellow, stalk and base brown, hairs pale. Wing membrane clear, veins pale brown, hairs of base of costa and of stem vein mixed white and black, the former predominant. Legs dark brown to black, cinereous-pollinose, with narrow bases of mid- and hind-tibiae, basal half to three-fourths of hind metatarsus and depression of pedisulcus yellow; hairs short, appressed, pale yellow or white, a few longer black hairs dorsally and posterodorsally on tibiae; tarsal segments mostly black-haired. Hind metatarsus about six times as long as broad. Calcipala small, rounded.

Abdomen cinereous-pollinose, paler laterally and below, vestiture pale



Figs. 1-7. *Simulium* (*Hagenomyia*) *longistylatum* n.sp. 1. Female terminalia, ventral, showing long hairs of seventh sternite. 2. Male terminalia, ventral. 3. Ventral plate, lateral. 4. Left coxite and style, lateral. 5. Parameres and associated structures. 6. Abdominal armature of pupa; dorsal, left; ventral, right. 7. Right respiratory filament of pupa, lateral.
Figs. 8-9. *Simulium* (*Hagenomyia*) *pictipes* Hgn. 8. Female terminalia, ventral. 9. Right respiratory filament of pupa, lateral.

yellow, with a few black hairs apically; the greatly narrowed third to fifth tergites and the membrane anteriorly on either side of them dull black, the resulting crossbands tapering laterally and about equal in width to second tergite.

Genitalia as in Fig. 1. Paraproct anterior to cercus very narrow, strap-like; ventral portion greatly expanded, subquadrate, highly polished, dark brown to black; posteroventral angle acutely pointed; anteroventral margin curved under; centre of expanded portion bare, its anteroventral surface with about ten scattered hairs; posterior margin with short, delicate fringe; under surface with a close-set clump of about 15 hairs. Cercus twice as wide as long, rounded posteriorly. Arm of genital fork slender, apical expansion arrowhead-shaped, with prominent anterobasal projection. Ovipositor lobes short, their inner margins subparallel and separated by a distance equal to their length.

Male.—Upper occiput not extensively black-haired behind vertex. Line between eyes with a sparse row of black hairs.

Disc of mesonotum dull black, margins and oblique stripes behind humeral depressions broadly cinereous-pollinose. Thoracic pattern inconspicuous. Hind metatarsus 4½ to five times as long as broad.

First and last abdominal segments dull greyish-black, remainder deep velvet black; sides of second, fifth, and sixth tergites broadly, of seventh and eighth narrowly cinereous-pollinose, the pollen with a niveous sheen. Sternites dull cinereous.

Genitalia as in Figs. 2-5. Coxite at inner ventral margin shorter than its width, greatly prolonged laterodorsally, becoming nearly twice as long as its ventral width. Style very long and slender, 1⅓ times as long as coxite, four times as long as its width at base, evenly tapered, with slightly convex median margin; basal half of inner (dorsal) surface with well-defined area of close-set, short hairs; apex rounded, slightly incurved, without tooth. Ventral plate in ventral view strongly bilobate, the posterior margin deeply indented, sides convex, basal arms moderately stout; in lateral view with a strong ventral keel at base of cleft; basal arms strongly bent ventrad. Median sclerite not bifurcate. Dorsal sclerite linear. Base of paramere very broad, irregular in outline, the arm with four or five large spines and a thick cluster of smaller ones near apex.

Pupa (Figs. 6, 7).—Length of body 4.0-5.0 mm., of respiratory organ 1.7-2.0 mm. Latter composed of nine short, inflated, evenly tapered filaments arising in four short-petiolate pairs and a single lateroventral stalk; filaments uniformly radiating outward and upward, median stalk of each median pair more swollen than others. Cocoon boot-shaped, with large opening greatly elevated above substrate and entirely enclosing pupal filaments.

Larva.—10.0-11.5 mm. In color and structure much like *pictipes* but anterior arms of X-sclerite, because of heavier pigmentation, appearing much stouter.

Holotype, ♂, Outardes River, Baie Comeau, Que., 21 July 1955, L. S. Wolfe, No. 6695 in Canadian National Collection, Ottawa.

Allotype, ♀, Manicouagan Depot, Baie Comeau, Que., 30 July 1955, B. G. Blair.

Paratypes, 33 ♂♂, 6 ♀♀, many pupae and a few larvae, Outardes River, 18-21 July, 22 ♀♀, English River, Manicouagan Depot, and Moose Creek, 25 July-10 Aug., all the foregoing at Baie Comeau, Que. 1955, L. S. Wolfe and B. G. Blair. 1 ♂, Orillia, Ont., 2.VIII.1924, H. L. Viereck. 3 ♂♂, Bala Falls, Bala, Ont., 14.IX.1925, G. S. Walley. Many pupae and pupal cases, Magnetawan River, Britt, Ont., 28.X.1956, J. J. Tibbles.

Other material: 1 ♀, Rupert House, Que., 30.VII.1949, E. J. LeRoux. 9 ♀ ♀, Great Whale River, Que., 27-28.VIII.1949, J. R. Vockeroth. 6 pupal cases, Muskrat Falls, Hamilton River, Goose Bay, Labr., 28.VII.1949, W. R. Richards.

Comments.—This species is not readily separable from *pictipes* except as follows: The pupal filaments are more inflated basally and somewhat longer in relation to the total length of the pupa, inflation being noticeable especially in the filaments arising near the ventral side (Figs. 7, 9). The male style is much longer than in *pictipes*, being four times as long as its basal width as compared with three times in *pictipes*. In *pictipes* the ventral plate, in ventral view, exclusive of the basal arms, is slightly more than half as long as wide, whereas in *longistylatum* it is almost as long as wide and the central cleft is proportionately longer and narrower (Fig. 2). The female paraproct of *longistylatum* is acutely pointed in the posteroventral region, that of *pictipes* being evenly rounded or at most with a slight angular projection (Figs. 1, 8).

Summary

Simulium (*Hagenomyia*) new subgenus, with *Simulium pictipes* Hagen as type species, is described and its position within the genus discussed with reference to external morphology, habits, and distribution. A new species from eastern Canada, *Simulium* (*Hagenomyia*) *longistylatum*, is also described and figured.

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Statistical Analysis of Percentages Based on Unequal Numbers, with Examples from Entomological Research

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Entomologists, like research workers in other fields, frequently wish to determine whether the percentage of individuals having a certain attribute (e.g., % eggs parasitized) is associated with some other variable, which may be either qualitative or quantitative. The numbers of individuals observed with and without this attribute are recorded for each category of the other variable. A test is made of the hypothesis that the true percentage or proportion of individuals with this attribute is the same in each category. One of the methods commonly used for this purpose is the χ^2 test of independence. If the calculated χ^2 exceeds a specified level of significance, the hypothesis is rejected; otherwise it is accepted. The test is described in most books on statistical methods, e.g., Goulden (1952).

Like all statistical tests, the χ^2 test of independence is valid under specific conditions. Failure of the data to satisfy these conditions can lead to serious distortion of the significance of the association between the variables, as illustrated below. Because of the frequent failure of field data to satisfy the rigid conditions of the χ^2 test, the more robust analysis of variance is usually more appropriate for data of this type. Occasionally this may require unequal weighting of the percentages when there is considerable variation in the numbers of individuals they represent.

An Example of Non-Binomial Variation and its Effect on the χ^2 Test

In a study of variation in the density of pine needle scale on spruce trees (Peterson, 1956), the following counts were made of infested and non-infested needles at each of three crown levels. A four-spiral sample was drawn from each crown level in each of nine trees; all needles considered here were from the same year's growth.

	Infested	Not Infested	Total	% Infested
Lower	355	266	621	57.2
Medium	673	379	1,052	64.0
Upper	727	418	1,145	63.5
Total	1,755	1,063	2,818	

The object was to test the hypothesis that the probability of a needle being infested is independent of crown level. Two tests of this hypothesis were made, (i) a χ^2 test of independence, applied to the row and column totals of the above table, and (ii) an analysis of variance of per cent infestation in individual samples.

The χ^2 test gave $\chi^2 = 8.91$ which, with two degrees of freedom, is close to the one per cent level of significance. On the basis of this test one would conclude that the observed percentages differed appreciably between crown levels, and the null hypothesis would be rejected. According to the analysis of variance, however, no significant crown level differences were demonstrated by the data; the F

value for levels was 1.86, with two and 16 degrees of freedom and a chance probability of 0.19. The divergent results may be explained with reference to the assumptions underlying each test.

In the analysis of variance it is assumed that the observed differences between crown levels are due not only to the effects of levels but also to components of variance due to (i) interaction between levels and trees and (ii) sampling variation within levels of individual trees. Both these components are therefore included in the error variance.

In the χ^2 test, the differences between crown levels are in effect tested against a theoretical binomial variance. It assumes therefore that (i) there is no interaction between crown levels and trees, and (ii) the probability of infestation is the same for all needles within a level of an individual tree. That at least one of these assumptions is incorrect is evident from the size of the error mean square in the analysis of variance. It was almost twice as great as binomial variance, indicating that the ordinary χ^2 test is definitely not valid for these data.

Percentages based on unequal numbers of individuals are of common occurrence in entomological surveys and field experiments. Occasionally these may need to be weighted if an efficient analysis of variance is to be made. What weighting procedure, if any, should be used depends on (i) the extent to which n varies and, if this variation is substantial, on (ii) the proportion, B, of the error variance accounted for by binomial variation.

The binomial variance of percentages is $p(100\text{-}p)/n$, so that $B = p(100\text{-}p)/ns^2$, where s^2 is the observed error variance of the percentages, p. When the n values are unequal, their harmonic mean may be used.

Effect of Unequal n on Unweighted Analysis of Variance

When the n values are reasonably uniform, equal weighting will provide an efficient analysis regardless of the composition of the error variance. Cochran (1943) has discussed the effect of unequal n in terms of the efficiency of an unweighted analysis if the variation were entirely binomial, i.e. if $B = 1$. For B less than 1, the efficiency would of course be greater than this.

"Efficiency" and "efficient" are used throughout this paper in the sense of Cochran's definition, which is as follows. Although he has treated both the one-way and two-way classifications, only the latter will be considered here. In a randomized block design with r treatments and s blocks, the expected treatment mean square, assuming no interaction, is

$$\sigma^2 + \frac{1}{r-1}\left\{N - \sum_i \sum_j (n^2_{ij}/N_{.j})\right\}\sigma^2_t$$

when binomial weights, n_{ij}, are used, and

$$\sigma^2 + s\,\bar{n}_h\,\sigma^2_t$$

when equal weights are used. Cochran defines the efficiency of the "equal weights" analysis of variance as the ratio of the coefficients of the treatment variance component, σ^2_t, i.e.

$$E = s(r-1)\bar{n}_h$$

where

$\bar{n}_h$ = harmonic mean of n_{ij} values
$= r\,s/\sum_i \sum_j (1/n_{ij})$,

n_{ij} = number of individuals in the i-th treatment in the j-th block,

$N_{.j}$ = total number of individuals in the j-th block.

Ratio of Binomial to Observed Variance

For E reasonably close to unity, equal weighting will be satisfactory, and no comparison of error variance with binomial variance is then necessary. However for E less than 0.9, Cochran suggests that the ratio of binomial to observed variance be estimated to determine what weighting procedure if any should be adopted. This estimated ratio may be written

$$B = \bar{p}(100 - p)/s^2 n_h,$$

where

p = mean of observed percentages,

s^2 = error mean square.

Cochran has investigated, for B values ranging from zero to 1, the relative efficiencies of (i) binomial weighting, i.e. weighting proportional to n, (ii) equal weighting, and (iii) partial weighting, in which he uses binomial weights for the lower third of the n values and equal weights for the top two-thirds. On the basis of his findings he recommends binomial weighting when more than 80 per cent of the error variance is binomial, equal weighting when less than 30 per cent is binomial, and partial weighting in the 30 to 80 per cent range. For two-way classifications he suggests equal weighting when as much as 50 per cent is binomial variation. It is noteworthy that partial weighting is not only simpler to apply than binomial weighting but that it provides a more efficient analysis in the intermediate range than either binomial or equal weighting. Likewise, in the case of a small fraction of binomial variation, equal weighting is the most efficient as well as the most convenient.

Examination of Percentage Data with Regard to Weighting Requirements

Since the method of weighting, if any, that is required for an efficient analysis depends on the ratio of binomial to observed error variance, it is of interest to determine what magnitude of ratios may occur in entomological field projects. A number of sets of percentage data from field experiments and sampling surveys were accordingly examined, with the results shown in Table I. Data based on unequal numbers of observations were chosen in order to indicate at the same time the relationship between the variation in n and the minimum efficiency of an unweighted analysis.

The first three sets of data are from chemical control trials in two orchards, using randomized block designs; the next three are from a stratified sampling study in an apple orchard; the others are from a stratified sampling study in a white-spruce shelter belt. In all the sampling data, crown levels were regarded as "treatments" for the purpose of calculating E.

As the B values indicate, binomial variation accounted for less than half of the observed variance in ten of the 14 bodies of data examined. In other words, only four sets would warrant consideration of a binomial or partial weighting procedure on the basis of this criterion. In these four sets, however, the values of n were sufficiently uniform to ensure a reasonably efficient analysis without the use of weights, with the possible exception of winter mortality of budmoth larvae and parasitism of budmoth eggs, for which the resultant loss in efficiency would be 16 and 13 per cent respectively.

Weighted Analysis of Percentages in a Two-Way Table

When a weighted analysis of percentages in a two-way classification has to be made, the method of fitting constants may be used. The procedure is described in many books on statistical methods (e.g. Goulden, 1952; Snedecor,

TABLE I

Examples of percentage data based on unequal numbers, with reference to the applicability of weighting procedures

Attribute observed	p[a]	Sample unit	No. of sample units	Range of n[b]	E[c]	B[d]
Infestation of logan plants with root borer larvae	64	Orchard plot	60	6–10	0.99	1.00
Injury to apples (early drops) by codling moth	16	Tree	48	120–597	.94	.10
Injury to apples (late drops, picks) by codling moth	3	Tree	48	714–2495	.95	.14
Winter mortality of budmoth larvae	68	100 Leaf-clusters	40	2–19	.84	1.00
Parasitism of budmoth eggs	33	100 Leaf-clusters	40	11–80	.87	1.00
Predation of pistol casebearer eggs	2	100 Leaf-clusters	40	132–519	.93	.37
Infestation of spruce needles (1955 Growth) with pine needle scale	84	4 Spirals	30	26–157	.89	.14
Infestation of spruce needles (1954 Growth) with pine needle scale	61	4 Spirals	27	41–189	.88	.57
Infestation of spruce needles (1953 Growth) with pine needle scale	37	4 Spirals	27	30–214	.88	.12
Infestation of spruce needles (1952 Growth) with pine needle scale	28	4 Spirals	18	17–189	.81	.15
Predation of adult females of pine needle scale on 1955 growth	79	4 Spirals	30	92–1553	.64	.02
Predation of adult females of pine needle scale on 1954 growth	67	4 Spirals	27	36–505	.71	.06
Predation of adult females of pine needle scale on 1953 growth	68	4 Spirals	24	20–273	.77	.16
Predation of adult females of pine needle scale on 1952 growth	72	4 Spirals	18	1–135	.30	.49

[a]Mean percentage of individuals observed with this attribute.
[b]Total number of individuals (with and without this attribute) per sample unit.
[c]Efficiency of unweighted analysis of variance (two-way classification) if $B = 1$; for $B < 1$, the efficiency is greater than this.
[d]Ratio of binomial to observed error variance; the latter represents inter-plot variation in the first entry, inter-tree in the next three entries, and intra-tree in all others.

1956). Goulden illustrates the method with data on percentage protein content of barley. While these are not binomial data, the method of analysis is the same.

If Cochran's partial weighting procedure is called for, the top two-thirds of the n_{ij} values will be all set equal to the smallest value (of the top two-thirds), which we may call n′. Their corresponding S_{ij} (Goulden, 1952, p. 346) are then obtained by multiplying p_{ij} values by n′. Alternatively, the n_{ij} values may all be divided by n′, resulting in fractional weights for the lower third and convenient weights for the top two-thirds.

Transformation

Percentages are frequently transformed to the arcsin scale before analysis, with the object of stabilizing the variance. This object will be achieved only if the error variance of p is equal or proportional to p(100-p), and if the arcsin values are weighted proportional to n_{ij} when these are unequal. Whenever the error variance is largely non-binomial, i.e., when B is small, the transformation is not likely to be of much use. Even when the variance is essentially binomial, the transformation will seldom be worth while if p is between 20 and 80 per cent, since the ratio of the largest to the smallest expected variance will then be less than 1.6 for constant n.

The probit (Winsor, 1948) and logit (Dyke and Patterson, 1952) transformations have been applied to percentage data from factorial experiments on the assumption that treatment effects will be more nearly additive on these scales. Each of these transformations, like the arcsin, is predicated on a specific mathematical model. Tests for the validity of these models are illustrated in the papers cited.

Summary

Percentage data from surveys and field trials often have an error variance that is considerably greater than binomial variance. Since the χ^2 test of independence assumes only binomial variance, it will then exaggerate the significance of "treatment" differences. The analysis of variance, however, assesses the differences against the empirical error variance and is therefore not subject to this bias. When the percentages are based on unequal numbers of individuals, consideration may need to be given to unequal weighting to ensure an efficient analysis of variance.

Weighting will be advantageous only when the number of individuals per "plot" varies markedly, and the probability of an individual having the attribute is uniform within plots. Transformations to arcsin values will be advantageous only when this probability is uniform within plots but varies considerably between plots, in particular when a number of the probabilities are outside the 20 to 80 per cent range.

It is the author's opinion, based on numerous sets of data in addition to those examined here, that most percentage data collected under field conditions can be satisfactorily analysed without the use of weights or transformations. However, when an unweighted analysis yields an error variance which is less than twice the magnitude of binomial variance, Cochran's criteria can be used to decide what weighting procedure, if any, to adopt.

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Notes on Anatomy, Life-history, and Behaviour of *Aphaereta pallipes* (Say) (Hymenoptera : Braconidae), a Parasite of the Onion Maggot, *Hylemya antiqua* (Meig.)[1]

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During studies at Ottawa on the physiology of the onion maggot, *Hylemya antiqua* (Meig.), 29 per cent of 2,320 puparia that had been collected in muck soil at Ste. Clothilde, Que., in the autumn of 1957 were parasitized by the braconid *Aphaereta pallipes* (Say)[2]. There are few reports of this insect's parasitizing Diptera in Canada and none on its life-history or behaviour. Hammond (1932) found it in first-generation puparia of the onion maggot at Ottawa. Wishart (1957) reared it from puparia of the cabbage maggot, *Hylemya brassicae* (Bouché), collected from St. Martin and St. Rose, Que. Notes on the biologies of two other species of *Aphaereta* have been published by Graham-Smith (1919) and Evans (1933), the former on *Aphaereta cephalotes* (Hal.) and the latter on *Aphaereta minuta* Nees. Both species are parasites of carrion-infesting Diptera.

Since the physiology studies at Ottawa required a supply of parasite-free larvae of the onion maggot, a knowledge of the biology of *A. pallipes* was of prime importance. This paper is a report on observations made on *A. pallipes* in the greenhouse and laboratory at Ottawa during the winter of 1957-58.

Methods

Field-collected puparia of the onion maggot were inspected microscopically and those containing pupae of *A. pallipes* were stored in moist peat moss at 40° C. until required. Adults of the parasite were obtained in four to eight days by incubating the chilled *H. antiqua* puparia on moist filter paper at 25° C. The adults were maintained at this temperature in a 7-x-4-inch, open-ended, glass container; fine-mesh nylon cloth stretched over the ends allowed adequate ventilation. No food was supplied. Water was provided by an absorbent cotton wick partially immersed in a closed vial of water. Under these conditions the adults lived for almost a week.

Mainly first-, second-, and third-instar larvae of the onion maggot were used as host insects. They were fed on slices of onion sets placed in the parasite cages. Parasitized larvae were removed daily, given a fresh supply of food, and incubated at 25° C. and 70 to 80 per cent R.H. for pupation. To obtain adult parasites, the puparia were incubated singly under similar conditions in small plastic cages. Second- and third-instar larvae of the house fly, *Musca domestica* L., and third-instar larvae of the cabbage maggot were occasionally used as host insects.

Anatomy

Adult.—*A. pallipes*, a rather dainty and graceful braconid, is glossy black with yellow legs; the two basal antennal segments are yellow (Fig. 1). Females (2.2 mm. long) are usually larger than males (1.5 mm.). The adults vary in size according to the amount of food consumed by the larvae; this depends upon the number of larvae feeding on a host and on the size of the host larva.

Egg.—When freshly laid, the egg is ellipsoidal with both poles slightly elongated; it measures approximately 0.25 mm. by 0.04 mm. Eggs float free in the body fluid of the host or become enmeshed among the muscle fibres or the

[1]Contribution No. 3883, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada.

[2]Identified by C. W. McComb, University of Maryland, College Park, Md.; the synonymy of the genus *Aphaereta* has been revised in his paper "New synonymy in the genus *Aphaereta* with a redescription of *Aphaereta pallipes* (Say)." Proc. Ent. Soc. Washington 60(5): 223-224. 1958.

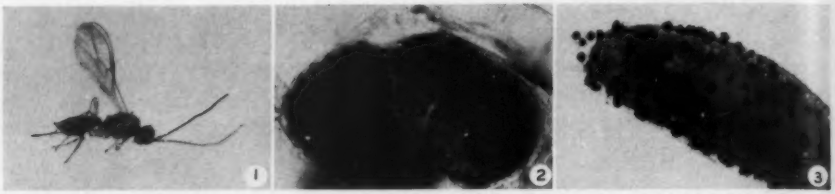

Fig. 1. *Aphaereta pallipes* (Say), ♀. Fig. 2. Two-day-old egg of *A. pallipes* surrounded by the nucleated trophamnion and closely applied to a trachea of the host. Fig. 3. Third-instar larva of *A. pallipes* showing the clumps of refractile granules.

fat bodies. They were frequently found closely associated with the tracheae or tracheoles of the host (Fig. 2).

The trophamnion, a nucleated membrane, is formed inside the chorion shortly after oviposition. The egg increases about five times in length during incubation and immediately before hatching measures about 1.3 mm. by 0.33 mm. The nuclei of the trophamnion also increase in size and measure about 0.034 mm. in diameter before the embryo hatches. No mitotic figures were seen in these nuclei.

Larva.—The first-instar larva has no tracheal system and the junction between the mesenteron and the proctodeum is closed. A pair of salivary glands opening just below the oral aperture extend backward along the mesenteron; a pair of malpighian tubules opening into the proctodeum extend forward below the salivary glands. A dorsal organ and a nervous system composed of a brain, a suboesophageal ganglion, and three thoracic and eight abdominal ganglia are present.

The second-instar larva closely resembles the first instar except that the sensory organs of the head are more elaborately differentiated.

The third-instar larva has a respiratory system composed of paired lateral trunks, each with eight abdominal and one thoracic spiracle. Large clumps of refractile granules are present among the fat bodies and can be clearly seen through the body wall (Fig. 3). Immediately before pupation, the larvae are about 3.0 mm. by 1.0 mm. in size.

Pupa.—Pupae are usually oriented parallel to the longitudinal axis of the host puparium with their heads pointed anteriorly. No cocoon surrounds the pupa. The eye-spots of the adult begin to turn red about two days after pupation, and they can then be clearly seen through the wall of the host puparium. The pupa is about 2.4 mm. long. Pigmentation of the body begins several days before emergence.

Life-history and Behaviour

The adults usually emerged by chewing one or more holes near the anterior end of the host puparium. Occasionally they emerged from the mid-region of the puparium, but no instance of emergence from the posterior end was noted. All the adults from one puparium usually emerged within an hour. Defaecation took place during emergence and the meconium remained in the host puparium.

From 54 host puparia studied, 516 parasites emerged; the ratio of males to females was about three to seven. The average number of parasites emerging from one host puparium was 10, the range being one to 21. Only males emerged from three of the 54 host puparia and only females from two of them.

Copulation began within a few hours of emergence and occurred frequently

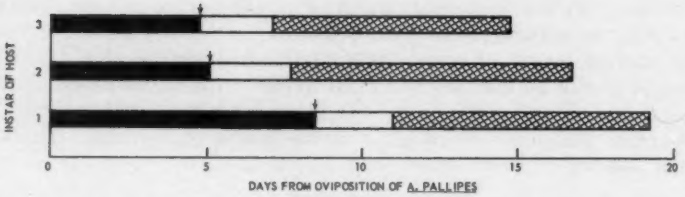

Fig. 4. Durations of immature stages of *A. pallipes* parasitizing the three instars of *H. antiqua* larvae reared at 25° C. and 70 to 80 per cent R.H.; solid bar, egg; open, larva; cross-hatched, pupa; arrow, pupation of host. Based on inspection of 10 to 20 hosts at each stage of development.

throughout the oviposition period. Some females mated several times with different males within a few minutes. The maximum time of copulation was about a minute.

The preoviposition period was at least two days. Ten third-instar larvae of the onion maggot were confined for 12 hours with 20 females and five males of *A. pallipes* when the parasites were one, two, three, and four days old. None of the larvae was parasitized by the adults one day old, five by those two days old, eight by those three days old, and all by those four days old. All ten larvae confined with virgin females were parasitized and only males, 92 in all, were produced.

A. pallipes oviposited in first-, second-, and third-instar larvae of the onion maggot. Apparently the female is attracted to the host larva by the onion odour but ultimately finds the host by a sense of touch. Movement of the host is important for oviposition; the parasites ignored immobile larvae. The description given by Evans (1933) of oviposition in *A. minuta* is very similar to that observed in *A. pallipes*. The female locates the host larva in the onion apparently by the vibration caused by the feeding larva and oviposits through the onion tissue. The host writhes only a few seconds after the ovipositor has been inserted and then becomes immobile. The female remains in the ovipositing position for up to five minutes and is not easily disturbed at this time. After egg-laying is completed, the host larva remains immobile for about a minute and then begins normal movement. The poison gland system of *A. pallipes* appears similar to that figured by Evans (1933) for *A. minuta*.

Some females each attacked several larvae during their lifetimes. The total number of eggs laid by a single female was not determined but as many as 20 eggs were found in one larva after it had been parasitized by only one female. Some host larvae were each attacked by several females within a few hours. Sixty eggs were dissected from a single larva although the maximum number of adult parasites emerging from a host puparium was 30.

Duration of the egg stage depends on the age of the host larva at oviposition since hatching occurs only when the host larva pupates. Fig. 4 shows that the average length of the egg stage is 8.5, 5.2, and 4.8 days for eggs laid in first-, second-, and third-instar *H. antiqua* larvae, respectively. Parasitism appears to stimulate pupation of the host since the average time from hatching to pupation of normal larvae of the onion maggot at 25° C. is 12 to 14 days.

The larval stage of the parasite lasts two to three days (Fig. 4). During this time the entire contents of the host puparium except the larval mouth hooks and the main tracheae are consumed. The size of parasite larvae depends on the number of larvae feeding on the host's tissues. *A. pallipes* larvae move little

during feeding and the third-instar larvae are usually oriented with their anterior ends towards the anterior end of the host.

The average length of pupal life varied from seven to nine days (Fig. 4). The average size of 10 host puparia from larvae of the onion maggot parasitized in the first and second instar was 5.7 mm. and 6.0 mm., respectively; puparia resulting from parasitized third-instar larvae measured 6.6 mm., the same size as normal puparia.

Discussion

The anatomy, life-history, and behaviour of *A. pallipes* are similar to those of *A. minuta* described by Evans (1933). However, adults of the former may emerge from one or more holes in the host puparium and the meconium is voided during emergence, not afterwards as in *A. minuta*. Stimulation of pupation was reported also by Holdaway and Evans (1930) and by Evans (1933) in parasitism of *Phaenicia sericata* (Meig.) by *Alysia manducator* (Panzer) and *A. minuta*.

The increase in size of the braconid egg within the host larva is well known and has been described by Jackson (1928), Vance (1931), Evans (1933), and others. The role of the trophamnion as a pneumatic membrane has been discussed by Ogloblin (1925). Nutrients from the host haemolymph must diffuse through this nucleated membrane to the embryo but the possibility that the membrane may be an organ of digestion has not been studied. The disassociation of the cells of the trophamnion after the embryo has hatched, their ability to accumulate fatty material from the body fluid of the host, and their final role as food for the parasite larva have been noted by Jackson (1935).

The hatching of *A. pallipes* may be under hormonal control since hatching occurs only during pupation of the host, when the concentration of the growth and moulting hormone is high and the juvenile hormone very low, or absent (Wigglesworth, 1954).

During the anatomical studies on the third-instar larvae, large masses of refractile granules, presumably metabolic waste products, were noticed scattered among the fat bodies. Preliminary tests indicated that these accumulations were composed mainly of urates.

Summary

In the laboratory, the braconid *Aphaereta pallipes* (Say) parasitized all the larval instars of the onion maggot, *Hylemya antiqua* (Meig.). The egg, larval, and pupal stages of the parasite are described. The adults mated readily. The females had a preoviposition period of at least two days. Only males emerged from host larvae parasitized by unmated females. The length of the egg stage varied from two to 10 days, depending on the age of the host larva when parasitized. The egg increased greatly in size during incubation and hatched only during pupation of the host. The larval period lasted two to three days and there were three larval instars; the pupal period lasted six to 10 days. Parasitism appeared to stimulate host pupation. The mesenteron is closed ventrally in the larval and pupal stages and refractile granules, presumably waste products, were found among the fat bodies; urates appeared to be the main components of these granules. The average number of parasites emerging from a host puparium was 10, the ratio of males to females being three to seven. *A. pallipes* also parasitized larvae of the house fly, *Musca domestica* L.

Acknowledgments

The author wishes to thank Mr. J. P. Perron, Science Service Laboratory, St. Jean, Que., for his generosity in supplying normal and parasitized puparia

of the onion maggot; and Mr. J. K. Campbell, Crop Insect Section, Entomology Laboratory, Ottawa, Ont., for his technical assistance.

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Mode of Feeding of the Larva of *Ctenicera aeripennis destructor* (Brown) (Coleoptera: Elateridae)[1]

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Though wireworms, the larvae of elaterid beetles, are among the most important agricultural pests, little is known about how they feed.

Langenbuch (1932) and Subklew (1934) made observations on the feeding behaviour of *Agriotes lineatus* (L.) and *A. obscurus* (L.). According to Langenbuch, *Agriotes* spp. cause a brush-like fraying of cereal stems, which results from the way in which the larvae squeeze the stems with their mandibles, ingest the fluids, and leave the fibres intact. *Ctenicera aeripennis destructor* (Brown), the most important wireworm species in Western Canada, causes similar injury to cereal crops. The stems are attacked underground and are shredded but not cut off.

Examinations of the gut contents of *Agriotes* spp. showed no evidence of any solid material (Langenbuch, 1932; Subklew, 1934). Subklew found only a more or less consistent, variably coloured fluid. He considered the absence of solid material in the gut, the thick oral filter, and the small, slit-like mouth as sufficient evidence to conclude that larvae of *Agriotes* ingest fluid food only. Langenbuch had previously concluded the same thing, but on the sole grounds that the gut contents did not include any solid material.

Woodworth (1938) found that larvae of *Limonius canus* Lec. which had fed on food pellets containing lampblack had particles of lampblack in their digestive tracts; graphite, with a slightly larger particle size than lampblack, was rejected.

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He did not give the size of these particles but I found that soot particles from an oil-fired furnace are as small as 2.2 microns in diameter and commercial graphite particles are as small as 3.3 microns. Woodworth also said that cornstarch, with a larger particle size than graphite, was never found in the digestive tract although corn is fed on readily by wireworms. The larvae commonly cleaned the starch completely from the seed coat, but left no rejected refuse. He concluded from this that either a very fine grinding or extraoral digestion takes place.

Dobrovsky (1954) made some observations with larvae of *Conoderus falli* Lane (as *vagus* Cand.) feeding on small pieces of potato on the surface of the soil. Potato pulp protruded dorsally between the mandibles forming a fibre that increased in length as the larva fed. He speculated that there are three possible explanations for this: the liquid portions are extracted and imbibed; some predigestion may occur by which some of the solids are liquefied and imbibed; or some solids are broken down mechanically and swallowed and the larger pieces are discarded.

All of these authors expressed ideas about how the species with which they were concerned fed, but their investigations were not carried far enough to give conclusive results. This paper is a report on how the larva of *C. aeripennis destructor* feeds and comparisons with the findings of other workers.

The Oral Filter

A dense oral filter of forward-projecting hairs has been noted in the larvae of *A. lineatus* and *A. obscurus* (Langenbuch, 1932) and *L. canus* (Woodworth, 1938; Lanchester, 1939). The presence of an oral filter in other species is implied by remarks of other authors about the density of the hairs on the mouth parts, that most are branched, and by their drawings (*Hypolithus bicolor* Esch. (as *nocturnus* (Esch.)), Arnason, 1931; *Tetrigus fleutiauxi* v. Zwal., Hyslop and Böving, 1934; *C. aeripennis destructor*, Glen, 1950; *Agriotes mancus* (Say) and *A. sputator* (L.), Eidt, 1954). I have examined six species of *Ctenicera* (including *C. aeripennis destructor*), the four of *Agriotes* mentioned above, two of *Hypolithus* (including *H. bicolor*), one of *Hypnoidus*, one of *Oestodes*, and *L. canus;* all have a dense oral filter of branched hairs.

Woodworth and Lanchester suggested that the filter in *L. canus* prevents the passage of large food particles. Woodworth even suggested that it is probably able to prevent the entry of undesirable soluble materials. Langenbuch suggested that, in addition to preventing the passage of solid materials, the oral hairs of *A. obscurus* and *A. lineatus*, by their capillary affinities, facilitate the absorption of soil moisture. The oral filter of *C. aeripennis destructor* is certainly able to prevent the passage of large food particles; potato and wheat starch granules, with a minimum size of about eight microns, were found enmeshed in the hairs of feeding larvae, but none were found in the gut.

Stomodaeal Modifications

The mouth of the larva of *C. aeripennis destructor* is small and transverse (Glen, 1950). I found that in a larva 16 mm. long the mouth is a slit about .09 mm. wide. It is bounded on the ventral side by the hypopharyngeal sclerome and on the dorsal side by a narrow, lightly sclerotized thickening of the base of the epipharynx. The sclerites fit tightly together and close off the digestive tract, except when the buccal dilator muscles separate them. The mouth of *L. canus* is similar (Woodworth, 1938).

The intima of the proventricular region shows no modification in *A. mancus*, *A. lineatus*, *A. obscurus*, *A. sputator*, or *C. aeripennis destructor*, and there

is but slight increase in musculature. A well-developed proventriculus is an adaptation usually associated with the digestion of solid food (Snodgrass, 1935).

The pharnyx of *C. aeripennis destructor* (described by Eidt, 1958) forms an elaborate pumping apparatus. The lumen is crescentic in cross section and is lined with a thicker intima on the ventral side. The dorsal and more flexible side is lifted by the buccal and pharyngeal muscles, dilating the lumen. The lumen is constricted by the contraction of the pharyngeal compressor muscles, which draw the sides of the pharynx together and force the dorsal wall downward. There is also a pair of cibarial muscles which, by lifting the epipharynx, increase the volume of the preoral cavity.

The musculature of the pharynx of the larva of *C. aeripennis destructor* is essentially the same as those of the larvae of *Parallelostethus attenuatus* (Say) and *Alaus* sp., which were described by Dorsey (1943). Other coleopterous larvae such as *Dytiscus marginalis* L. (Burgess, 1883; Rungius, 1911; Korschelt, 1923-1924), *Lampyris noctiluca* L. (Vogel, 1915), and *Claviger testaceus* Preyssl. (Vogel, 1915), have a sucking pump formed largely of the pharynx. The first two species are predacious and suck the juices and liquefied body contents of their prey through hollow mandibles. I found that the pharynx of *C. aeripennis destructor* is remarkably similar to that of *L. noctiluca*; the principle of operation of both is based on the flexibility of the dorsal wall (or "sucking fold", to use Vogel's term). *C. testaceus* lives with, and is fed regurgitated food by, ants of the genus *Lasius*. *C. aeripennis destructor* is an herbivore.

Gut Contents

Sections of the guts of *A. mancus* and *C. aeripennis destructor* as well as of the red-backed cutworm, *Euxoa ochrogaster* (Guen.), were stained with safranine and fast green, common botanical stains, and with Delafield's haematoxylin and eosin. Plant material was readily detected in the cutworm gut even without stain; many cells were intact and easily identified by the thick cell walls. Plant material was not visible in the wireworm guts; only unidentified globules of fluid that were not removed by the reagents used were present.

Smears and water mounts of the gut contents of *C. aeripennis destructor* that had fed recently on wheat kernels or potato showed no solid material and tests with iodine indicated no starch or cellulose. Smears of the gut contents of *Tenebrio molitor* L. larvae feeding on potato tuber, on the other hand, contained starch granules and cellular debris. Smears of the gut contents of *Leptinotarsa decemlineata* (Say) feeding on potato leaves contained pieces of whole tissue with the cell walls and leaf hairs intact.

Frequently wireworms are observed with dark material in the gut, which is visible through the body wall. In *C. aeripennis destructor* this is caused by unidentified, opaque, dark-coloured or highly refractive globules of fluids that contrast with the translucence and light colour of the fat body.

The faeces are fluid and contain small particles that are probably bacteria and waste material in the form of globules and crystals. None of these particles exceeded three microns in diameter.

Extraoral Digestion

Feeding specimens of *C. aeripennis destructor* frequently regurgitated a droplet of brownish fluid when handled. The fluid is probably ventricular in origin, for the ventricular epithelium is highly glandular and the ventriculus in feeding larvae contains large amounts of similar fluid. It is not salivary, for the larvae have no salivary glands (Eidt, 1958). Lanchester (1939) noted that

digestive fluid is commonly found in the preoral cavity of *L. canus* and that salivary glands are absent. He has seen it to be discharged from the stomodaeum.

The regurgitated fluid (and the intestinal fluid) from *C. aeripennis destructor* contained amylase and hence has a digestive function. This was demonstrated by mixing in a well slide a droplet of the fluid with a drop of soluble starch substrate prepared according to the directions of Swingle (1925). It was hydrolysed to give no colour with iodine in less than one hour at room temperature. Amylase was chosen for this study because it is easy to test for and because wheat kernels and potato tubers contain large amounts of starch.

The ventricular fluid was regurgitated also by larvae that were undisturbed during feeding. Scrapings from the ends of tunnels in potato tubers, where wireworms had been feeding shortly before the samples were taken, contained much amylase. With approximately the same amount of soluble starch substrate and scrapings in each case, tunnel scrapings hydrolysed the substrate to give no colour with iodine in 20 minutes, whereas no colour change was perceptible after 24 hours with scrapings from undamaged portions of the same tubers. Starch-sugar conversions take place in potato tissue and it therefore contains amylase, but in very much smaller amounts than in the tunnel scrapings. The tunnels tested were fresh and did not contain other organisms (such as nematodes) that might have produced amylase.

As any insect whose digestive juices contain amylase may leave a deposit of amylase on its food, the test for amylase on the feeding site was repeated with larvae of *L. decemlineata* feeding on potato leaves, adults of *Camnula pellucida* (Scudder) feeding on dandelion leaves, and larvae of *T. molitor* feeding on potato tuber. Although the digestive juices of all three contain amylase, none of them left a deposit of amylase.

Any of these three species may possibly deposit digestive fluid but subsequently ingest all of it. *T. molitor*, however, which provides the best comparison with *C. aeripennis destructor*, rasps the cut surface of a potato tuber, leaving a rough surface littered with debris. It is therefore probable that if *T. molitor* deposited digestive fluid it would not all be ingested.

The regurgitated fluid of *C. aeripennis destructor* did not cause perceptible breakdown of fresh potato starch granules because the granules are protected by amylopectins. In the preceding tests, whole starch granules that were present did not show corrosion after 24 hours. The starch granules of potato are still available as a source of carbohydrates because amylase hydrolyses amylopectin, although it takes a long time to do so. Potato and wheat starch granules that are broken by the mandibles apparently hydrolyse somewhat faster than whole ones. This was shown by subjecting crushed and whole granules from the oral filter to the action of the regurgitated fluid. In half an hour the crushed granules gave a reddish-purple colour with iodine, indicating some hydrolysis, whereas whole granules gave a dark-blue colour, indicating no hydrolysis. Langenbuch (1932) concluded that *A. lineatus* and *A. obscurus* could not digest starch because regurgitated fluid from the gut would not corrode potato starch granules after 24 hours.

Direct observations of feeding larvae are difficult to make because exposed larvae attempt to hide by burrowing and usually bury their heads in their food. Limited observations were made by pouring thin agar plates in petri dishes, filling the rest of each dish with dry soil, and introducing several larvae. When the dishes were inverted the larvae were seen feeding on the agar: the larvae bit off a piece and then backed away from it; they rolled the agar between their man-

dibles while, presumably, the regurgitated fluid acted upon it. During this time violent pulsations of the digestive tract (about 30 per minute) were seen through the thoracic integument. The undigested refuse was discarded.

The larvae were not seen to regurgitate the fluid in agar blocks, but did so in triple-strength gelatin blocks. Further observations on feeding were not possible in the latter medium because it became too fluid at room temperature and the larvae became immobilized.

Conclusions and Summary

The larva of *C. aeripennis destructor* does not ingest solid materials, with the possible exception of particles under three microns in diameter, but takes its nourishment in fluid form. This is indicated by the following findings: the preoral cavity contains a dense filter of branched hairs through which solids, with the exception of very fine particles, cannot pass; the mouth opening is a very small, transverse slit that can be opened or closed; the proventriculus is poorly developed; the pharynx is modified to form a sucking pump; the gut does not contain solids; the faeces are fluid and contain only very small particles under three microns in diameter; the larva is able to carry out extraoral digestion.

The probable mode of feeding is to masticate the tissue, to regurgitate fluid containing enzymes, and then to imbibe the plant juices and products that are liquefied or made soluble by enzymatic action.

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New Pyralidae from the Papuan Region (Lepidoptera)[1]

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The following new species have been found in material submitted from various sources for identification.

***Glyphodes obscura*, new species**

Figs. 1, 9, 13

Head, body and wings above moderately dark greyish brown, wings with a faint purplish sheen, hind wing a little paler and somewhat translucent in basal two-thirds. Markings very obscure. Fore wing above: antemedial band weakly fulvous, dark-bordered, somewhat oblique; discocellular patch obscure, quadrate; postmedial band weakly fulvous, dark-bordered, outwardly oblique to anal fold, then retracted to lower angle of cell and again outwardly oblique to inner margin; an obscure dark subterminal line, almost parallel to margin; a narrow dark terminal line; fringe a little paler than wing, with a dark midline. Hind wing above: a distinct dark dot at lower angle of cell; a very obscure, regular, postmedial band; traces of a dark, crenulated, subterminal line; terminal line and fringe as on fore wing. Fore wing beneath: base and disc paler than above; antemedial line lacking; discocellular marking dark, geminate, joined posteriorly to the inner end of postmedial line; the latter dark, roughly L-shaped, the part behind the discocellular patch obsolete; termen and fringe as above. Hind wing beneath: much as above, but discocellular dot obscure and postmedial band dark, not fulvous. Female a little paler than male. Expanse 40 to 44 mm.

Male genitalia. Uncus long and rod-like, decurved, weakly expanded at tip with a corona of short setae above and with coarse hairy vestiture below; tegumen broad, irregularly domed; vinculum moderately wide, irregularly contorted; transtilla strap-like, narrowed and raised in an inverted V in middle; valve broad, distally expanded, with a large, decurved, spine-like clasper; coremata large; penis short, aedoeagus poorly sclerotized, vesica with a forked, barbed cornutus.

Female genitalia. Ovipositor lobes slender, regular, finely pilose, flanked by a row of longer, coarser setae; apophyses short; ostium simple; ductus long and slender, gradually expanding, with a sclerotized collar near ostium, followed by a contorted area; bursa globular, membranous, a patch of small spines at junction with ductus, and two impressed, elongate, weakly sclerotized, spinulose signa.

Holotype, male, and allotype, female, War, Tami R., near Hollandia, Netherlands New Guinea, March 10 and 11, 1937; one male paratype, Uskwar, Bewani Mts., Netherlands New Guinea; Type lot no. 114, Carnegie Museum, Pittsburgh.

One male paratype, Tami R., Mar. 11, 1937; one female paratype, War, March 12, 1937; one male paratype, Leon E. Schultzefluss, Sepik District, New Guinea, June, 1912. Type no. 6716, C.N.C.

One male paratype, Ramu R., New Guinea; one female paratype, Standlg-a-Aprilfluss, Sepik District, New Guinea, Sept., 1912. Berlin Museum.

This species is related to *Glyphodes umbria* Hampson, but differs in the more evenly rounded wings, in the duller colour and more obscure maculation, and particularly in the complete absence of the dark striations and blotches so characteristic of *G. umbria*.

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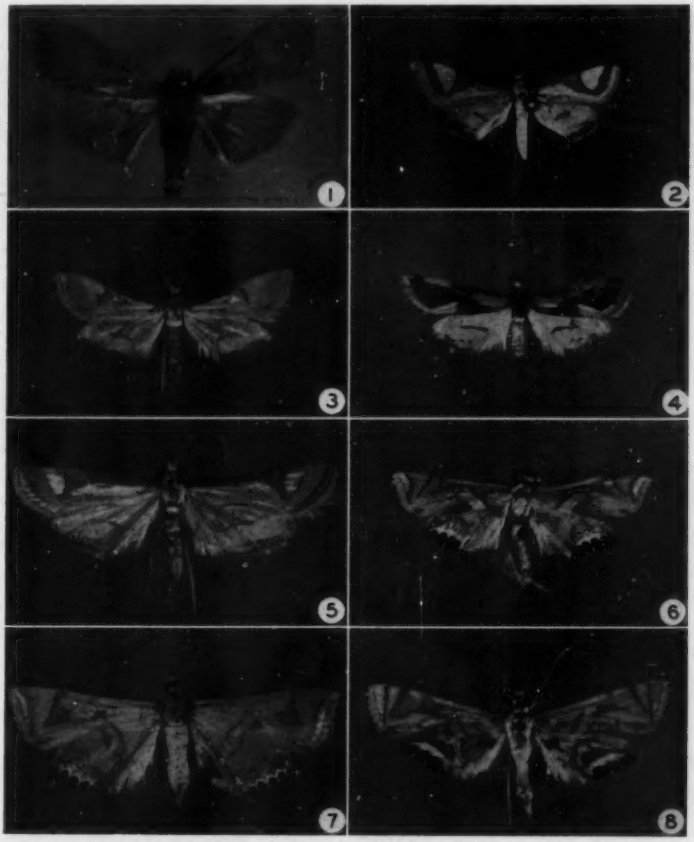


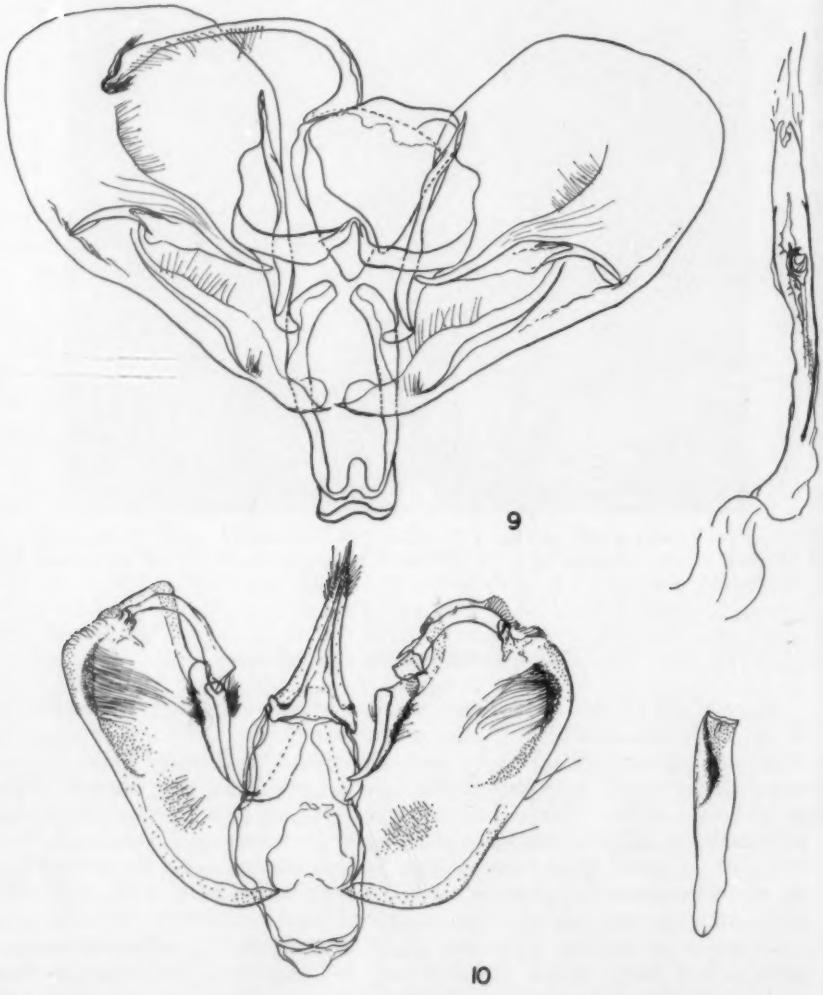
Figs. 1-8. 1, *Glyphodes obscura*, x 1; 2, *Eoophyla latipennis*, x 2; 3, *E. latifascia*, x 2; 4, *E. thomasi*, x 2; 5. *E. persimilis*, x 2 6, *Margarosticha papuensis*, x 2; 7, *M. aurantifusa*, x 2; 8, *M. nesiotes*, x 2.

Eoophyla latipennis, new species

Figs. 2, 14

Female. Frons flat and oblique, antenna weakly annulated with scales, R_1 free, R_5 stalked briefly with R_{2+4}, cell of fore wing about half length of wing, M_2 and M_3 of hind wing stalked; wings unusually broad. Frons, vertex and dorsal surface of thorax white; palpi and tongue light greyish buff; body beneath white; legs whitish buff; fore tibia and tarsal segments tipped with fuscous. Fore wing above white; a light-fuscous band along costa from base to beyond cell; from distal part of costal band a broad light-fuscous triangle over discocellulars to Cu_2, there joining a light-fuscous postmedial band; the latter with inner edge almost straight, outer edge curved parallel to outer margin of wing, the band narrowing to its junction with discocellular triangle, there stopping abruptly; a yellowish-buff band, widest before middle of wing, along inner margin from just beyond base to tornus, there joining a yellowish-buff outer-marginal band of even width; the outer-marginal band inwardly bordered by a black line and

bearing black terminal dots between veins; fringe grey, basal portion darkest. Hind wing above white; weak fuscous and yellow dusting in anal area; a black, slightly curved postmedial line from M_2 to 1st A; a broadly oval pale-yellow patch beyond postmedial line, becoming suffused with orange towards margin, and divided from an apical pale-yellow zone by an arcuate band of the ground colour; a silvery submarginal band on the yellow zone from M_1 to 1st A, staggered basad on Cu_1 and Cu_2; black marginal spots in cells M_1 to Cu_1 and a dash in Cu_2; fringe grey, with a darker basal line, the latter much darkened in the zone opposite marginal spots. Under side white, with markings of upper side very faintly repeated. Expanse 15 mm.



Figs. 9, 10. Male genitalia. 9, *Glyphodes obscura;* 10, *Eoophyla latifascia.*

Female genitalia. Ovipositor broad, rather sparsely setose; apophyses very slender, straight; bursa globular, membranous, finely denticulate, with two broad, longitudinal, heavily spinulose bands.

Holotype, female, Dojo, near Hollandia, Netherlands New Guinea, April 9, 1958, R. T. Simon Thomas and G. den Hoed, Leiden Museum. One female paratype, same data, No. 6740, C.N.C.

It is likely that this and the three following species will eventually be removed from *Eoophyla* but a generic classification of this section of the Nymphulinae must await the study of much more extensive material now at hand. The present species can be distinguished from all that resemble it by the unusually broad wings.

***Eoophyla latifascia*, new species**

Figs. 3, 10, 15

Radial veins of male fore wing depressed at end of cell, the latter somewhat distorted; frons flat and oblique; antenna weakly annulated with scales; R_1 and R_5 free in both sexes; M_2 to Cu_1 of fore wing from lower angle of cell; hind wing with M_2 free. Head and body above white, a fuscous stripe from eye to base of fore wing; labial palpus fuscous, tipped with buff, and with some white scales at base beneath; maxillary palpus fuscous and fulvous, tipped with buff; proboscis white-scaled at base; body beneath white, legs tinged with buff. Fore wing above white, a fuscous stripe along costal margin to beyond cell; a black oblique line from costa to beyond lower angle of cell, a narrow, triangular, fuscous zone adjacent to it basad; a broad yellow patch anterior to inner margin in middle of wing; a broad, orange, submarginal stripe from costa to cell Cu_2, weakly bordered outwardly with fuscous, the stripe broadest in middle, tapering to a point behind; an orange marginal stripe of even width, bordered inwardly by a black line and bearing marginal black dots between veins; fringe grey. Hind wing above white to beyond middle, the whole terminal area yellow, shading to orange at middle of termen; yellow area bordered inwardly by a strong black line from M_2 to 1st A; a white, fuscous-bordered subapical crescent; four black marginal dots in cells M_1 to Cu_1, the middle two immediately preceded by round, black-bordered, silver spots; a marginal black dash in cell Cu_2; margin rather strongly excised in cell M_1; fringe grey with a darker basal line, the latter becoming pale in excision and at anal angle. Wings beneath white, markings of upper surface weakly repeated. Expanse 16 to 19 mm.

Male genitalia. Uncus moderately narrow, tapering, decurved laterally; gnathos articulating with tegumen, slender, dorsally spined at tip; juxta large, broadly bilobed. Valve broad; costa basally inflated, excavated before apex; outer margin slightly excavated behind apex; sacculus narrowly inflated; a large, strongly bent process from near outer margin, directed anteriorly then basad to rest against prominence at middle of costa; a patch of hairs before posterior angle. Penis short, cylindrical, lightly sclerotized; vesica weakly denticulate.

Female genitalia. Ovipositor broad and soft, lobes very sparsely setose; apophyses short, straight, pointed anteriorly; bursa very small, membranous; ductus bursae comparatively wide, of moderate length, fluted, with a sclerotized collar.

Holotype, male, allotype, female, and 17 paratypes, Dojo, near Hollandia, Netherlands New Guinea, April 9, 1958, R. T. Simon Thomas and G. den Hoed. Holotype, allotype and 12 paratypes in Leiden Museum; five paratypes, type no. 6741, C.N.C.

This species is close to *Aulacodes flavofascialis* Hampson but has the postmedial band of the fore wing wider and brighter orange. The type series shows no appreciable variation in this respect.

***Eoophyla thomasi*, new species**

Figs. 4, 16

Male unknown. Frons flat and oblique; fore wing with R_1 stalked with R_{2-4}, R_5 free; M_1 and M_2 long-stalked on both fore and hind wings. Frons, vertex, antenna and anterior part of thorax above orange; a minute, fuscous, oblique streak in front of antenna; an obscure fuscous stripe from eye to base of wing; palpi orange with some fuscous scales; base of tongue orange-scaled; posterior part of thorax above fuscous; abdomen above buff; body below and legs orange-buff, legs with some fuscous scaling above. Fore wing above fuscous to beyond cell, a large orange patch filling basal two-thirds of cell and continued behind it to near posterior margin; a broad V-shaped fuscous band from costa at end of cell to Cu_2 in submarginal area, then retracted parallel to outer margin to reach costa before apex; a white zone behind V-shaped band, followed by orange to inner margin; a narrow white submarginal band, parallel to outer margin, beginning behind costa and ending at 1st A; an orange marginal band of even width, joining V-shaped band anteriorly and orange tornal patch posteriorly, separated from white submarginal band by a black line and bearing black marginal dots or dashes between veins; fringe grey, with a darker basal line. Hind wing above white to beyond cell; terminal part of wing orange; between M_2 and 1st A the boundary between white and orange marked by a black line; a white subapical spot; outer margin excised in cell M_1; in each of cells M_2, M_3 a black marginal spot preceded by a black-bordered silver spot, usually contiguous with marginal spot, but sometimes separate in M_2; a well-developed black marginal spot in cell Cu_1 and a minute one in cell Cu_2; a lead-coloured, outwardly black-bordered submarginal line before marginal spots in cells M_2 and Cu_2, broken at veins Cu_1 and Cu_2; fringe grey, darker opposite cells M_2 to 1st A and with a darker basal line in this area; a black spot on basal fringe line anterior to each marginal spot. Wings beneath with maculation of upper side repeated, but in much paler and less contrasting colours. Expanse 16 to 18 mm.

Female genitalia. Ovipositor rather slender, moderately setose; apophyses slender, weakly curved, pointed anteriorly; bursa elongate, membranous, finely denticulate, with a pair of linear, denticulated signa; ductus bursae slender, with a small well-defined, incomplete collar about one-third of the way from ostium to bursa.

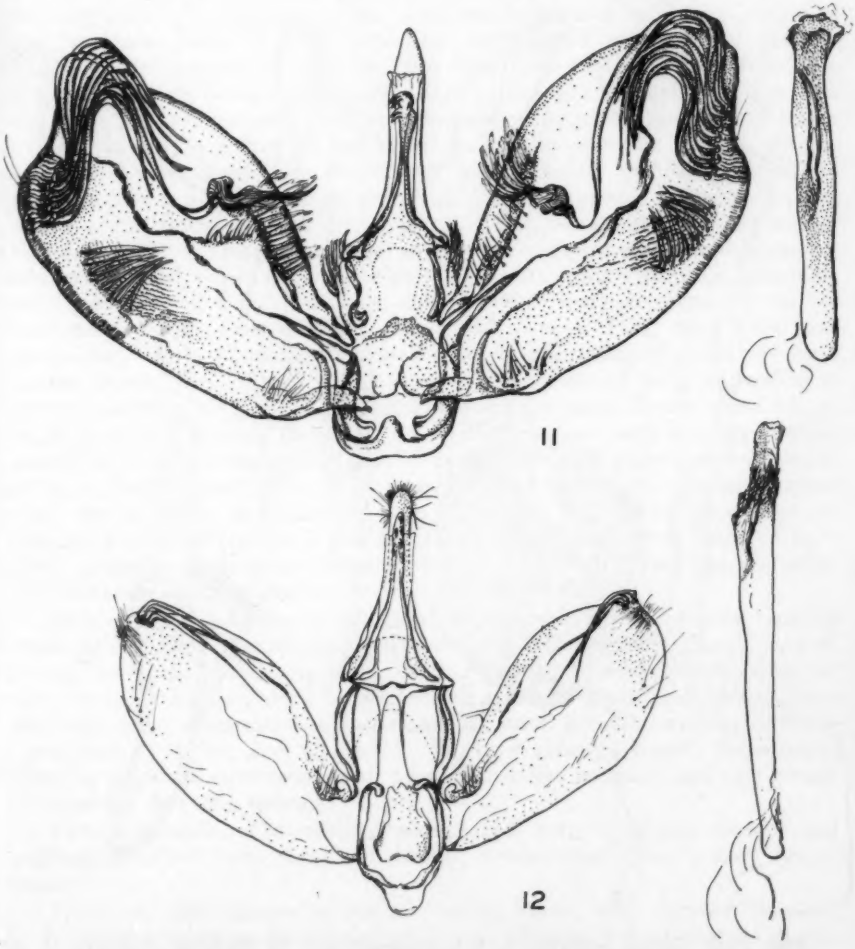
Holotype, female, and two female paratypes, Dojo, near Hollandia, Netherlands New Guinea, April 9, 1958, R. T. Simon Thomas and G. den Hoed, Leiden Museum; two female paratypes, same data, type no. 6742, C.N.C.

***Eoophyla persimilis*, new species**

Figs. 5, 17

Male unknown. Female with R_1 of fore wing free, M_2 and M_3 separate in fore wing, stalked in hind wing. Head, thorax, legs and abdomen light buff. Wings moderately narrow; fore wing above white; a light-fuscous stripe on costa to postmedial band; from costal band a triangular patch over discocellulars to Cu_1, its outer margin diffusely darker and somewhat excavated; an orange-yellow stripe from base to tornus, upcurved in medial and postmedial areas, and bordered posteriorly in medial area by an inconspicuous black line; the yellow stripe expanded to touch discocellular triangle and to join postmedial band; post-

medial band orange-yellow, weakly bordered on both sides with fuscous, beginning on costa near apex, almost straight, slightly oblique and tapering to cell Cu_2, there joining orange-yellow band from base; terminal band orange-yellow, of even width, bordered inwardly by a fuscous line, outwardly by a series of terminal dots midway between veins, expanded into a line towards tornus; fringe buff. Hind wing white to just beyond end of cell; a yellow band from base in anal area, running to join the broad, yellow, terminal band; the latter shading to orange at middle of termen, bordered inwardly by a black line from in front of M_2 to behind Cu_2; a white subapical crescent; termen incised in cell M_1; a minute black terminal dot just behind incision; larger black terminal spots in cells M_2 to Cu_2, those in M_2 and M_3 square and each immediately preceded by a round, fuscous-rimmed, silver spot, that in Cu_1 round and preceded at a short distance by an ovate, fuscous-rimmed, silver spot, that in Cu_2 comma-



Figs. 11, 12. *Margarosticha* spp., male genitalia. 11, *M. papuensis;* 12, *M. aurantifusa.*

shaped and preceded by an elongate fuscous spot; fringe light grey, with a fuscous line in base from incision to behind 1st A. Under surface white, with markings of upper surface very weakly indicated. Expanse 20 to 23 mm.

Female genitalia. Ovipositor very weakly lobed, soft, weakly setose; apophyses slender; ductus bursae narrow and slightly sclerotized near ostium, anteriorly membranous and greatly expanded, with a broad sclerotized collar adjacent to bursa proper; the latter membranous, rather narrow, with two spinulose, claw-shaped signa, one behind the other.

Holotype, female, and three female paratypes, Dojo, near Hollandia, Netherlands New Guinea, April 9, 1958, R. T. Simon Thomas and G. den Hoed, in the Leiden Museum. Two additional female paratypes, same data, type no. 6745, C.N.C.

Figs. 13-16. Female genitalia. 13, *Glyphodes obscura;* 14, *Eoophyla latipennis;* 15, *E. latifascia;* 16, *E. thomasi.*

This species closely resembles *Eoophyla costifascialis* (Hampson), new combination, but differs in the less definite fuscous outer border of the discocellular patch of the fore wing, in the greater production of the patch along the costal stripe, and in the narrower yellow marginal band of the hind wing, the band beginning beyond the cell, and not traversing its apex as in *E. costifascialis*. A considerable series of *E. costifascialis* was taken at the same place and time as the type series of *E. persimilis*, and the differences, although slight, seem constant.

***Margarosticha papuensis*, new species**

Figs. 6, 11, 18

Male with mid-tibia enlarged and containing a long hair-pencil in a groove; a pair of large hair-pencils on under surface of first abdominal segment. Frons white, stained with yellow in front of antennae; vertex white; occiput fuscous behind eye; palpi fuscous, joints broadly tipped with white; thorax above light fuscous, a white stripe across patagium and tegula; abdomen above with first two segments light fuscous, a white semicircular patch on posterior margin of first; segments three to seven yellowish buff, eighth segment and genitalia fuscous; body beneath silvery-white; legs light buff, fore tarsus and tibial segments tipped with fuscous. Fore wing above fuscous; a lead-coloured line from base along anterior margin of cell; a wedge-shaped white sub-basal band, oblique from inner margin at base to cell before middle; a somewhat oblique, silvery-white, brown-bordered band from inner margin before middle to middle of cell, expanded in some specimens along anal fold; a crescentic, almost transverse, silvery-white band in end of cell; a silvery-white, brown-bordered, outwardly oblique band from costa beyond cell to cell M_3; a silvery-white, wedge-shaped, subterminal band, edged inwardly with brown, outwardly with black, extending from costa to cell Cu_1; an oblique, shining, silver mark at tornus; a row of black terminal dots between veins; fringe leaden grey. Hind wing with basal third silvery white, containing a brown triangle, and delimited outwardly by a narrow brown line; a broad orange band across middle of wing, expanding at tornus; a shining silver band bordering the orange band distally from M_1 to 1st A, posteriorly turning distad and broadening to outer margin; a large, white, postmedial area, its inner portion heavily dusted with dark purplish-brown scales, giving a bluish overall effect; a clear white band before the row of terminal spots; the latter five in number, in cells M_1 to Cu_2, the middle three large, all oval and black; between each pair an orange submarginal patch followed by a silvery-white marginal patch; fringe leaden grey. Under surface greyish white, with markings of upper surface showing through weakly.

Male genitalia. Uncus of moderate width, parallel-sided, distally tapering to a somewhat blunted acute apex; gnathos arising from tegumen, fingerlike, with a weak, rhomboidal, distal expansion, bearing a group of several dorsal spines at apex; juxta rectangular; valve broad, bearing a tuft of short hairs behind costa near base, and a subterminal tuft of numerous stout, parallel hairs, arising from a prominence, at first directed costad, then bent abruptly basad. Penis cylindrical, of moderate dimensions, with a heavy tusk-like cornutus and two groups of numerous very fine spines.

Female genitalia. Ovipositor weakly lobed, soft; apophyses slender and weakly sclerotized; bursa long and narrow, a sclerotized collar a little before ostium.

Holotype, male, Bisianumu, Sogeri Plateau, Papua, 1600 ft., July 28, 1957, G. P. Holland; allotype, female, Bainyik, Sepik District, New Guinea, Oct. 28, 1957, E. G. Munroe and G. P. Holland; numerous paratypes from various

localities in the Territory of Papua and New Guinea, type no. 6737, C.N.C. Also three paratypes from Dojo, near Hollandia, Netherlands New Guinea, April 9, 1958, R. T. Simon Thomas and G. den Hoed, two in the Leiden Museum and one in the C.N.C.

This species is closely related to *M. sphenotis* Meyrick from Australia (wrongly identified by Hampson as *Cataclysta australis* Felder and Rogenhofer, a much smaller species from Fiji), but differs in the brighter orange coloration, the more elongate marginal spots of the hind wing, and the more extensive white band preceding the marginal spots. It is very common all over the mainland of New Guinea.

***Margarosticha aurantifusa*, new species**

Figs. 7, 12, 19

Male without hair-pencils. Head, thorax and abdomen above orange; palpi orange-buff, second joint of labial palpus with a fuscous band; body beneath and legs whitish buff, fore tibia and tarsal segments narrowly fuscous-tipped. Fore wing broader and more angular than in *M. papuensis;* ground colour above bright orange; a black sub-basal dot; a weakly defined, silvery, fuscous-bordered band from inner margin to cell, somewhat expanded on anal fold and followed by an oblique silvery line in end of cell; a silvery postmedial triangle, weakly bordered externally with fuscous; a silvery, weakly fuscous-bordered, subterminal band, straight from costa to just before tornus, then abruptly bent basad; a terminal row of black dots between veins; a leaden-grey fringe. Hind wing above orange; a silvery, fuscous-bordered band across disc; a large, ovate, white patch before outer margin, bordered inwardly and anteriorly with silvery scales, and heavily dusted with purplish scales so as to appear bluish grey; five black terminal spots in cells M_1 to Cu_2, the spaces between them orange, followed by silver; fringe lead-grey, a black spot in base of fringe between first and second, second and third, and third and fourth terminal spots. Under side light orange, markings of upper side weakly repeated. Expanse 21 to 25 mm.

Male genitalia. Uncus long, basally tapering, distally parallel-sided, rounded at tip; gnathos slender and rod-like, with four or five dorsal spines distally, in two rows; valve broadly ovate, costa and sacculus weakly inflated, an apical tubercle bearing three stout, recurved setae; penis of moderate width, slightly narrowed before tip, tip densely spinulose.

Female genitalia. Ovipositor weakly lobed, soft; apophyses slender and weakly sclerotized; bursa slender and membranous; ductus with a weak, sclerotized collar a little before ostium.

Holotype, male, Bainyik, Sepik District, New Guinea, Oct. 27, 1957, E. G. Munroe and G. P. Holland, type no. 6738, C.N.C. Allotype, female, Dojo, near Hollandia, Netherlands New Guinea, April 9, 1958, T. R. Simon Thomas and G. den Hoed, in the Leiden Museum.

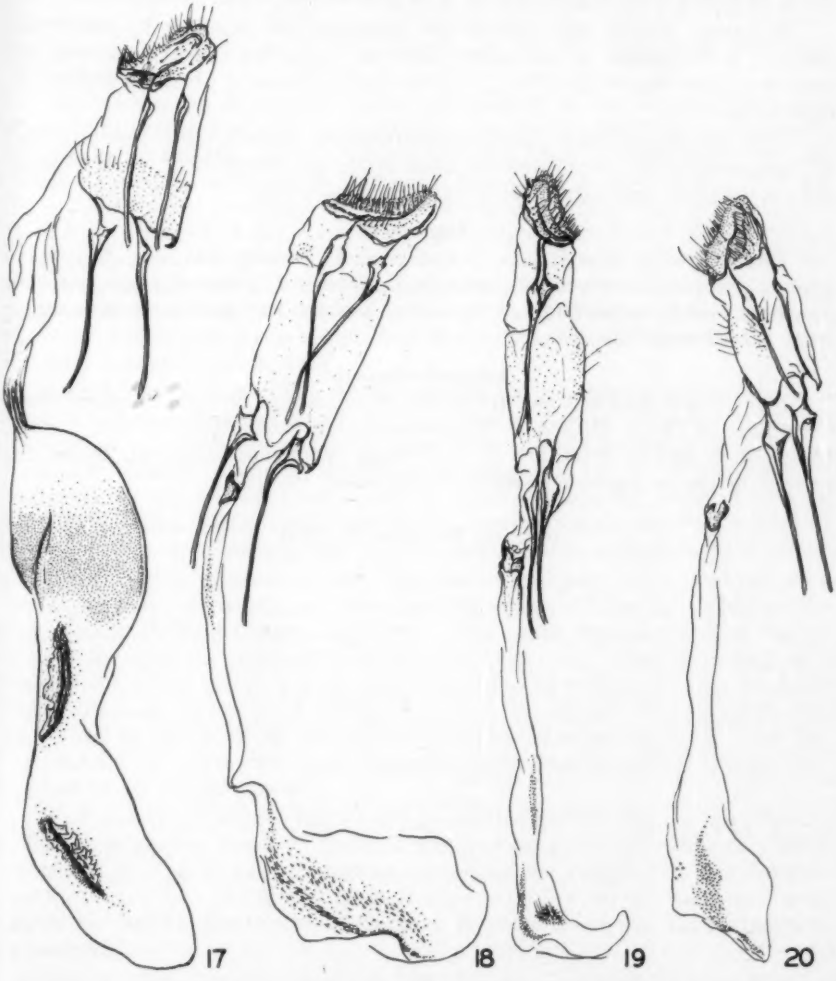
This species is larger and broader-winged than *M. papuensis,* is more broadly suffused with orange, and has very different genitalia.

***Margarosticha nesiotes*, new species**

Figs. 8, 20

Head above cream-coloured, frons stained with yellow in middle; labial palpus cream-coloured, with weak fuscous rings on second and third joints; thorax and abdomen above cream-coloured with some yellowish-orange scaling; body beneath white, legs pale buff, fore tibia and tarsal segments tipped with fuscous. Fore wing above light orange-yellow; an oblique, silvery-white,

brown-bordered, wedge-shaped band from inner margin at base to cell before middle; a silvery-white, brown-bordered band from inner margin before middle to cell, with an outward expansion on anal fold, and an oblique band from its apex to lower angle of cell; a broad, oblique, triangular, brown-bordered, silvery-white patch from costa beyond end of cell; a wedge-shaped, fuscous-bordered, silvery-white, subterminal band from costa to cell Cu_1; a lead-coloured dash in anal fold at tornus; a row of black subterminal spots between veins; fringe lead-coloured. Hind wing above white; an oblique, fuscous, antemedial band from cell to near anal margin; a slightly sinuous, orange-yellow, fuscous-bordered band from above lower angle of cell to anal angle of wing, there losing its fuscous border and extending forward for a short distance along outer



Figs. 17-20. Female genitalia. 17, *Eoophyla persimilis;* 18, *Margarosticha papuensis;* 19, *M. aurantifusa;* 20, *M. nesiotes.*

margin; a pearly band adjacent distally to fuscous border of orange band from Cu_1 to 2nd A; a band of fuscous dusting from apex of wing to pearly band at Cu_1; continuing along distal edge of pearly band to anal fold; an orange-yellow apical patch; five large, conjoined, black, terminal spots, bordered basally with narrow zones of orange-yellow, fuscous and greenish-nacreous scales, and separated on margin by small triangles of pearly-white scales; a pearly-grey patch on margin between last terminal spot and anterior end of orange band; fringe lead-grey, with a pearly zone opposite anal fold, followed by a white anal section. Under surface white, markings of upper side showing through faintly; black terminal spots of hind wing distinct, separated by white lines on veins.

Female genitalia. Ovipositor broad, sparsely setose; apophyses rather slender; bursa long and membranous; ductus with a weak sclerotized collar.

Holotype, female, and two female paratypes, St. Matthias I., June, July, 1923, A. F. Eichhorn, in the Leiden Museum. One female paratype with the same data, type no. 6739, C.N.C., and one in the Carnegie Museum, Pittsburgh, type lot no. 122.

This species is easily distinguished from *M. argyrograpta* Hampson and *M. papuensis* by the more extensive white markings, especially of the hind wing, and by the large, fused, marginal spots of the hind wing.

Summary

The following eight species of Pyralidae are described as new: *Glyphodes obscura*, *Eoophyla latipennis*, *E. latifascia*, *E. thomasi*, *E. persimilis*, *Margarosticha papuensis*, and *M. aurantifusa*, all from New Guinea, and *Margarosticha nesiotes*, from St. Matthias Island.

Acknowledgments

I am much indebted to Mr. Harry K. Clench, Carnegie Museum, Pittsburgh, Pa., to Dr. A. Diakonoff, Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands, and to Prof. Dr. E. M. Hering, Zoological Museum, Berlin, for permitting me to examine material in their care.

(Received December 23, 1958)

A Note on *Megachile centuncularis* (Linn.) in Wisconsin (Hymenoptera : Megachilidae)

By J. T. MEDLER[1]

Records on *Megachile centuncularis* (Linn.) were obtained in connection with research on pollination of alfalfa in Wisconsin. At no time abundant, specimens were collected while tripping alfalfa flowers in Bayfield, Brown and Dane Counties. One bee tripped 95 per cent of the alfalfa flowers visited and the earliest record was June 9th in Dane Co. Other flower records included fireweed, *Epilobium angustifolium* L., and goldenrod, *Solidago* sp. In Ontario, Pengelly (1953) found a female on sow thistle at Guelph, and observed a few specimens on alfalfa at Cayuga; alfalfa flowers were visited at the rate of 26-28 per minute and tripping efficiency was 99-100 per cent. Mitchell (1935) listed flower records that indicated a generalized habit, but the bee showed preference for composites.

The widespread distribution of *M. centuncularis* in the more northern part of the Holarctic Region may be associated with the species having considerable adaptability in nesting habits. Putnam (1864, quoted by Packard, 1869) observed a foundress working 20 days on a nest under a roof board. "On the 28th of July, upon removing the board, it was found that the bee had made thirty cells, arranged in nine rows of unequal length, some being slightly curved to adapt them to the space under the board. The longest row contained six cells, and was two and three-quarters inches in length; the whole leaf-structure being equal to a length of fifteen inches. Upon making an estimate of the pieces of leaf in this structure, it was ascertained that there must have been at least a thousand pieces used."

Gentry (1874) described a nest containing six cells placed horizontally at a depth of three inches below the surface of the ground. Another nest was constructed in the abandoned cells of a mud-dauber wasp (probably *Sceliphron*). These are doubtful records, according to Mitchell (1935). A specimen of *centuncularis* was reared from a nest in a dead stem by Hicks (1926, as *infragilis*). Michelbacher and Hurd (1954) reported on the habitual nesting of this species in a metal guide groove of a casement window at Berkeley, California.

In Wisconsin, a foundress was observed in late July, 1952, working on a nest in a carpet roll which had been inserted against a rafter of a shed on the Holt farm in Bayfield County (Fig. 1A). The carpet was removed on August 1, at which time the nest contained 30 cells (Fig. 1B). The plant used as a source for the leaf pieces was not ascertained, but of interest was the inclusion of an occasional flower petal among the green leaf pieces. Flower petals also are utilized by the species in Europe, according to Crèvecoeur (1952). The first four and the last three cells were removed for laboratory rearing and the nest replaced in its original location.

This species apparently has a habit of profuse leaf-cutting, as many pieces of leaf were used to construct the cells and provide partitions. Prihoda (1946) reported that 50 sq. cm. of leaf surface are utilized for a single cell. In Bohemia and Moravia, when the leaf material is obtained from young hardwood trees (especially beech), the loss of as much as 50 per cent of the leaf surface can be harmful.

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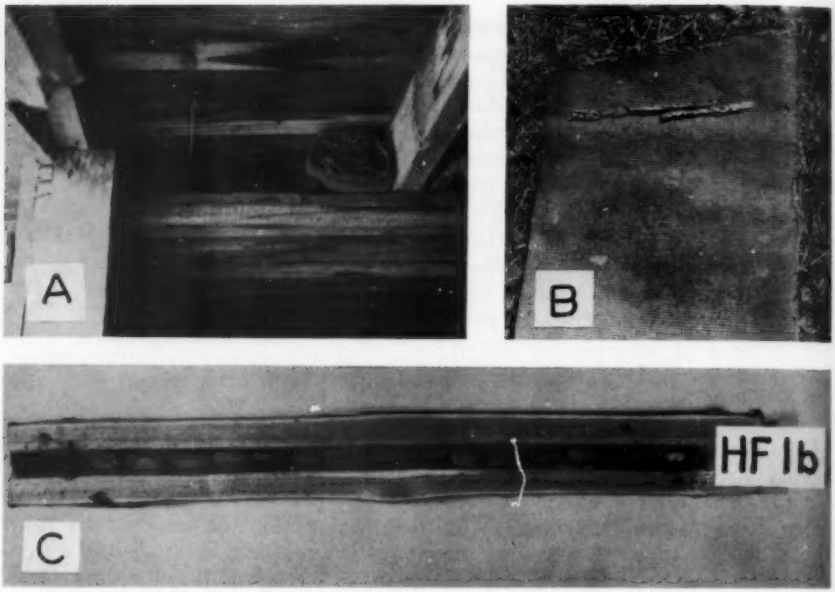

Fig. 1. (A) Nesting site of *M. centuncularis* in a horizontal roll of carpet, and (B) arrangement of cells in the unrolled carpet. (C) Sumac stick trap-nest with a 15-cell nest.

Several nests of *M. centuncularis* were obtained in sumac stick trap-nests of the type described by Medler and Koerber (1958). The cells were transferred singly to glass vials for rearing of adults in the laboratory. The data (Table I) show that females preceded males in cell sequence, but that nests occurred with either all females or all males. As the maximum number of cells in the cavity of an eight-inch sumac stick is 15 (Fig. 1C), and the species is capable of constructing at least 30 cells, it is believed that all-female or all-male nests are partial nests. This especially might be true for nests 3 and 4 which occupied sticks side by side in a bundle.

Only those trap-nests placed at rather open locations were utilized. Nests 6-9 were on fence posts in open pasture, and 3-5 were on small trees at the edge of a narrow windbreak. The Bayfield County nests (Nos. 1 and 2) were from sticks placed on the wall of a shed on the Holt farm, where the observations on the carpet roll nest were made in 1952.

A specimen of the parasite *Coelioxys moesta* Cress. was reared from nest 5. Attacks of *Melittobia chalybii* Ashm. also took place, but probably were due mostly to contamination in incubators. Two of the outer cells from the nest in the carpet roll produced *Dibrachys* sp. and a third cell contained two specimens of *Ptinus* probably *hirtellus* Sturm. Previous reports on parasites of this species include *Melittobia megachilis* (Packard) (Packard, 1869) and *Monodontomerus montivagus* Ashmead (Michelbacher and Hurd, 1954).

Gentry (1874) postulated that the pupa overwintered. Nests taken in September, however, contained cocoons with fully developed larvae, destined to overwinter in diapause. Observations on the life cycle are incomplete, but

TABLE I

Rearing record of *Megachile centuncularis* (Linn.) from trap-nests; showing sex of emerging bees, cell sequence and parasitism.

Nest number	County and year	Cell number											
		1	2	3	4	5	6	7	8	9	10	11	12
1	Bayfield, 1955	♂	♂	♂	♂	♂	♂	†	†	†	†	p	
2	Bayfield, 1956	♀	♀	♀	♀	♀	♀	♀	♀	♀	♂	♂	†
3	Washburn, 1955	♀	♀	♀	♀								
4	Washburn, 1955	♀	♂	♂	♂	♂	♂	♂	♂				
5	Washburn, 1955	♀	♀	p	♀ Cm								
6	Lafayette, 1956	♀	♀	p	p	†	♂	p	♂	♂	†		
7	Lafayette, 1956	†	♂	♂	†	♂	♂	♂	♂	♂	†		
8	Manitowoc, 1956	♀	♂	♂	p	♂	♂	♂					
9	Manitowoc, 1956	♀	†	†	♂	†	p	p	†				

† = larva died during rearing; Cm = *Coelioxys moesta* Cresson; p = *Melittobia chalybii* Ashm.

the absence of nests in trap-nests until late July and August would suggest that the species has only one generation in northern Wisconsin.

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(Received November 3, 1958)

Notes on Insects, Especially *Gymnaetron* spp. (Coleoptera: Curculionidae), Associated with Toadflax, *Linaria vulgaris* Mill. (Scrophulariaceae), in North America[1]

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Linaria vulgaris Mill., known commonly as toadflax or butter-and-eggs, is worldwide in its distribution but is a serious weed only in the Canadian provinces of Alberta, Saskatchewan, and Manitoba (Zilke and Coupland, 1954), where it is increasing in importance (Beck, 1954; Carder, 1956; Forbes, 1957). Smith (1956) correlated its relative insignificance as a weed in the other provinces and in the northwestern United States with the occurrence of the curculionid beetle *Gymnaetron antirrhini* (Payk.). Investigations on this and other insects that feed on toadflax and an evaluation of their possible use as biological control agents are reported in this paper; also included are some observations on the weed and its natural enemies made since 1950 in all provinces west of Quebec and in the northwestern United States.

The phylogenetic isolation of *L. vulgaris* from crop-plant species makes it suitable to control by imported insects as these may be expected to feed on the weed but not on crop plants.

Gymnaetron antirrhini (Payk.) (Coleoptera: Curculionidae)

This small, grey weevil was described by Paykull in 1800 and studied in its native Eurasia by Reitter (1907) and Hustache (1931). The first published record of its collection in North America is for Massachusetts in 1909 (Pierce, 1919; Buchanan, 1937). The earliest collected specimens in the Canadian National Collection were obtained in 1917 at Montreal, Quebec, and in 1932 at Parry Sound, Ontario.

G. antirrhini appears to occur where *L. vulgaris* occurs in the northeastern and northwestern United States and in all Canadian provinces except Manitoba, Saskatchewan and Alberta. Adult beetles were obtained in British Columbia, Washington, Idaho, and Montana from all but one of the toadflax infestations that were observed from 1951 to 1957, the records being new ones for these regions. The weevil was not encountered in a survey in Saskatchewan in 1953 by Loan (unpublished) or in 1956 and 1957 surveys by the author in Saskatchewan and Alberta.

In southern Ontario the adults overwinter beneath debris or in the old toadflax seed capsules in which they developed the previous autumn. Feeding on the young shoots of toadflax begins in May or early June. Mating occurs in early June but oviposition in the immature toadflax ovaries cannot begin until August, when destruction of the buds by a nitidulid beetle, *Brachypterolus pulicarius* (L.), subsides; this is discussed below. The females, while inside the corollas, insert the eggs singly through the pericarps. The formation of a conical protrusion one millimetre in height and diameter at each puncture on the plant ovary indicates that secretion of a growth regulator may accompany oviposition. Ovules, varying in number from eight to 17, adjacent to each puncture were affected simultaneously and became ovoid, much distended, and watery yellow in colour, in contrast to the green, discoid, healthy seeds. The eggs remain suspended within the cones on the pericarps. The freshly-hatched larvae begin feeding on these inactivated ovules, which constitute their entire food source at least until the final moult, though Louis-Marie (1957) reported

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that they fed on the fertilized ovules. A symbiont found in the mid-intestine of *Gymnaetron* sp. (Buchner, 1928) apparently enables the larvae to feed exclusively on the ovules that are inactivated by the growth regulator. The mature larvae construct ovoid cells of loosely cemented fragments of the placentae. These serve as pupal cases and, later, as overwintering sites for the adults.

The only available record of a natural enemy in North America was given by Krombein (1938), who found nests of the sphecid *Cerceris nigrescens* Smith at Buffalo, New York, stocked with adults of *G. antirrhini* (up to 25 in a single soil tunnel) and two other curculionid species. No parasites or predators were observed on any stage of *G. antirrhini* during the present investigation. Its hymenopterous parasites in Europe, *Triaspis flavipalpis* (Wesm.), *T. obscurellus* (Nees) and *Eurytoma aterrima* (Schrk.) (Hustache, 1931), are not recorded in North America (Muesebeck *et al*, 1951).

The absence of *G. antirrhini* from the toadflax areas of the Prairie Provinces may be because the mean annual minimum temperature is 20 degrees Fahrenheit below that of southern Ontario, southern British Columbia, or the northwestern United States. An alternative explanation is that the beetle was left behind when toadflax seed was introduced into the Prairie Provinces and has not yet moved into these areas. If so, it might become established if colonized; its host plant specificity, as outlined below, indicated complete safety in re-distributing the weevils within Canada. To test this hypothesis, 4,000 adults collected near Belleville were transported in mid-July, 1957, to the west by automobile in small cages in an ice-cooled container with fresh foliage. Two thousand were released at Marsden, Saskatchewan, and 2,000 at Codesa in the Peace River district of Alberta. These localities were the loci of early toadflax infestations in both provinces. One generation of weevils was completed in each of the new colonies before the autumn freeze-up. In August, 1958, the population at the release site in the Peace River district was encouraging; thirty-seven eggs, larvae, pupae and adults, or an average of 0.69 per seed capsule, were obtained from two small collections at Codesa. None was found at Marsden, Saskatchewan, however.

To test the host specificity of *G. antirrhini*, 100 flowers in each of 63 infestations of *L. vulgaris* and *L. dalmatica* (L.) Mill. in British Columbia and the northwestern United States were examined. Beetles were found commonly in all infestations of the former but very rarely on the latter and then only when *L. vulgaris* occurred within 50 yards. However, a narrow-leaved form of *L. dalmatica* in British Columbia and Washington had all stages of the beetle in numbers comparable to those on *L. vulgaris*.

Also, flowers of various Scrophulariaceae in gardens near Belleville were examined at frequent intervals in 1957 for *G. antirrhini*. These are: *L. vulgaris*, *L. dalmatica* (broad- and narrow-leaved forms), *L. maroccana* Hook. (varieties Golden Gem, Ruby King, Northern Lights, and Fairy Bouquet), *Antirrhinum majus* L. (varieties Yellow Jacket, Rock Hybrid, and Giant Tetra), *Cymbalaria muralis* Gaertn., Mey. and Scherb. (=*L. cymbalaria* (L.) Mill.), and *Chelone lyonii* Pursh. Each plant of *L. vulgaris* invariably contained several individuals of one or more stages of the beetle but apparently none of the other plant species was even visited by an adult, though within 50 feet of *L. vulgaris*. In mixed populations of *Chaenorrhinum minus* (L.) Lange (=*L. minor* (L.) Desf.) and *L. vulgaris* growing in a railroad cinder bed at Belleville, only the latter species was infested.

The host specificity of *G. antirrhini* was further tested in a greenhouse before the species was transferred to the Prairie Provinces. The same scrophulariaceous species that were observed in the Belleville gardens were cultured in duplicate in separate flower pots. These were confined in screened cages each with 70 adults of *G. antirrhini* and held at temperatures of 65°F. to 75°F. Within 12 days all aerial portions of *L. vulgaris* and *L. maroccana* were destroyed by the beetle, and the broad- and narrow-leaved forms of *L. dalmatica* were severely damaged. Injury to *A. majus* was insignificant until all growth of the *Linaria* species had been halted and then it, too, was damaged. There was no apparent feeding on *C. muralis* or *C. minus* at any time.

***Gymnaetron netum* (Germ.) (Coleoptera: Curculionidae)**

This species of *Gymnaetron*, also a native of Europe, was described by Germar in 1824. Buchanan (1937) reported specimens from Connecticut, New York, New Jersey, Pennsylvania, Virginia, and Iowa. Dozens of specimens collected by the author in the state of Washington in 1954 and 1955 together with two, also from Washington, in the collection of G. Stace-Smith, (personal communication), Creston, British Columbia, are new locality records for western North America. Two colour variants, ash-grey and olive brown, described by Hustache (1931) were found in approximately equal numbers. All stages of the beetle were found in the seed capsules of *L. vulgaris* and the narrow-leaved form of *L. dalmatica* in Washington. Unlike *G. antirrhini*, the adults emerged from the pericarps through holes chewed through the sides and not by way of the apical pores.

In a small plot in Washington that contained mixed populations of *L. vulgaris* and narrow- and broad-leaved forms of *L. dalmatica*, *G. netum* occurred abundantly on the first two but not on the third, in numbers approximately equal to those of *G. antirrhini*. None was observed in the vast infestation of the broad-leaved form of *L. dalmatica* (Lange and Wolfe, 1954) that surrounded this small plot. This host selection by two species of *Gymnaetron* indicated the existence of two varieties, if not species, of *L. dalmatica*, though taxonomically they are regarded as one. However, Coupland and Alex (1954) obtained only broad-leaved forms from seeds collected in Saskatchewan, Alberta, British Columbia, Idaho, and Washington.

Four adults, obtained in 1957 near Belleville during the collection of *G. antirrhini*, are new Canadian records for this species.

***Brachypterolus pulicarius* (L.) (Coleoptera: Nitidulidae)**

First described by Linnaeus in 1758, this small, black beetle is native to Europe and was given the common name European nitidulid by Britton (1922). Hervey (1927) reported the earliest collection in North America in New York State in 1919 and considered the insect to be a recent introduction. In 47 localities in British Columbia, southwestern Alberta, and the northwestern United States in which *G. antirrhini* was collected, *B. pulicarius* was found only in two, both in Montana. It was collected in Eastern Canada in New Brunswick and many parts of Ontario. A survey of the insect fauna of *L. vulgaris* in Saskatchewan (Loan, unpublished) and subsequent surveys by the author extending into Alberta showed *B. pulicarius* to be present in every sample of the weed taken.

The life-history and taxonomy of *B. pulicarius* were adequately described by Notman (1920), Hervey (1927), Hatch (1928), and Parsons (1943).

Serious damage to toadflax by *B. pulicarius* was twofold in Saskatchewan (Selleck *et al*, 1957) and Ontario. The early, succulent, terminal growth of the

plants was largely destroyed, resulting in extensive stooling. Later, most of the flower buds were destroyed, but after mid-August flowering was normal, apparently as a result of a decline in the population of the insect.

Adults of two species of Hymenoptera were associated with the larvae of *B. pulicarius* in the flowers at Belleville: *Platygaster* sp. near *melanocera* (Ashm.), and an apparently undescribed species of *Cephalonomia* sp. that may be a parasite of the nitidulid.

Observations at Belleville that the adults feed in flowers of *L. vulgaris*, dandelion, and strawberry but reproduce only on the first of these confirmed reports by Britton (1922) and Hervey (1927). The presence of *B. pulicarius* on *L. vulgaris* only, among the various Scrophulariaceae in the Belleville flower gardens, provided further evidence of this. At Saskatoon and Landis, Saskatchewan, however, the beetle reproduced commonly on the broad-leaved form of *L. dalmatica* though well isolated from *L. vulgaris* which might serve as a source of infestation for the beetle.

***Endothenia hebesana* (Wlk.) (Lepidoptera: Olethreutidae)**

Larvae of this small moth were collected in Quebec and Ontario in seed capsules of *L. vulgaris;* garden snapdragon, *Antirrhinum majus* L.; and pink turtlehead, *Chelone lyonii* Pursh. From one to 18 per cent of the seed capsules of these plants were destroyed. The insect was not encountered by Loan (unpublished) or the author in any of the western provinces or the northwestern United States. It is a general seed feeder and is consequently unsuitable for transfer to Western Canada as a possible control agent against toadflax.

A few adults of the parasite *Scambus indagatrix* Cresson (Hymenoptera: Ichneumonidae) were reared from larvae collected at Belleville.

***Formica neogagates* Emery (Hymenoptera: Formicidae)**

This black ant occurred commonly on toadflax flowers at Belleville. Workers punctured the long spurs to obtain the nectar but appeared to cause little damage. Many were collected within the corollas that contained larvae of *B. pulicarius* but were not observed to attack them.

Other Species

The following insects were collected in small numbers during the present investigation but were not significant factors in the natural control of toadflax:

Thysanoptera: *Taeniothrips inconsequens* group, *Thrips tabaci* Lind., *Aeolothrips fasciatus* (L.). Hemiptera: *Orius insidiosus* (Say), *Phymata wolffi wolffi* Stål, *Phymata pennsylvanica americana* Melin, *Phymata* sp., *Corimelaena montana* (Van D.), *Corimelaena pulicaria* (Germ.), *Liocoris lineolaris* (Beauv.), *Liocoris borealis* Kelton, *Poecilocapsus lineatus* (F.), *Plagiognathus obscurus* Uhl., *Capsus ater* (L.), *Campylenchia latipes* Say, *Philaenus leucophthalmus spumarius* (Fall.), *Cuerna striata* (Walk.), *Chlorochroa uhleri* Stål, *Cosmopepla bimaculata* (Thom). Coleoptera: *Brachyrhinus ovatus* (L.), *Tychius stephensi* Schönh. *O. insidiosus* and *Phymata* spp. are predacious. The other species are phytophagous but occurred in populations too small to exercise significant control of the weed.

Summary

The weevil *Gymnaetron antirrhini* (Payk.) is evidently the most important factor in the natural control of *Linaria vulgaris* Mill. in the eastern provinces of Canada, British Columbia, and the northwestern United States. The weed is usually economically unimportant where the beetle is found. In Saskatchewan and the Peace River district of Alberta, however, where the nitidulid *Brachypterolus pulicarius* (L.) is very common but *G. antirrhini* is absent, the weed is

a rapidly increasing menace to agriculture. Colonies of the weevil were released in these regions in 1957 and attained an average population of 0.69 per seed capsule in August, 1958, at the release site in the Peace River district. *G. netum* (Germ.) was recorded for the first time in Canada and in the United States west of Iowa; in Washington State it, with *G. antirrhini*, reproduced readily on *L. vulgaris* and on a narrow-leaved form, but not on a broad-leaved form, of *L. dalmatica* (L.) Mill.; the existence of two varieties or species of the plant was indicated by this host preference.

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Three New Records of Aphids (Homoptera : Aphididae) in British Columbia[1]

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Myzocallidium riehmi (Börner) was collected from sweet clover at Creston in June, 1957. This is the first time this aphid of potential economic importance has been identified from British Columbia. It occurs throughout the United States (Russell, 1957); in Ontario, Ottawa being near the northern limit of its range (W. R. Richards, in litt.); and was identified for the first time from Manitoba in 1956 (Bird and Robinson, 1957).

Pentatrichopus thomasi H. R. L. was identified from strawberry in British Columbia in 1957. Until recently two very similar species of *Pentatrichopus* living on strawberry in North America had both been identified as *P. fragaefolii* (Cock.). The main morphological difference between them is the presence of two rows of marginal capitate hairs on the anterior abdominal tergites of the apterous viviparae in one species and of four rows of these hairs in the other. Cockerell's type has two rows of these hairs and the name *fragaefolii* must, therefore, apply to this species. The other species has been named *thomasi* (Hille Ris Lambers, 1953, pp. 72-73). *P. thomasi* was taken in association with *P. fragaefolii* in strawberry fields in the Fraser Valley and on Vancouver Island.

Rungsia agropyrella (H. R. L.) was collected from couch grass at Agassiz (September 12, 1956), from Canada thistle at Creston (July 19, 1957), and from lawn grass at Vancouver (September 26, 1957). In 1956 this species was recorded as new to North America, having been first collected in New Brunswick in 1950 (MacGillivray, 1956). It was found in Manitoba in 1956 (Robinson, 1957). The aphid is capable of causing severe damage to grass.

Dr. W. R. Richards, Entomology Division, Ottawa, made or confirmed all the identifications.

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A New Species of *Paradacerla* from Mexico, and Synopsis of the Genus in North America (Hemiptera : Miridae)[1]

By LEONARD A. KELTON[2] AND HARRY H. KNIGHT[3]

Carvalho and Usinger (1957) divided the North American genus *Dacerla* Signoret, 1881, into two. *Dacerla* now contains those species with a spinelike projection on the posterior margin of the pronotum, and *Paradacerla* Carvalho and Usinger contains those species without a spinelike projection.

In this paper *Paradacerla* species and *Dacerla mediospinosa* are compared, especially concerning the genitalic characters, and a new species, *P. hirsuta*, is described. Distinguishing external characters of the species and a key to *Paradacerla* are provided.

Paradacerla Carvalho and Usinger, 1957

Type species of genus: *Paradacerla formicina* (Parshley, 1921)

The species of the genus are recognized by the antlike appearance, the flattened frons and the triangular head, and the very short hemelytra. The prominent pronotal spine found in *Dacerla* is absent. The amount and type of pubescence vary with the species.

The genitalia of the species are distinctive. The male and female genitalia are very closely related to those of *Dacerla*, and indeed the differences in the genitalia appear to be no greater between *Dacerla mediospinosa* (Figs. 1, 5, 8) and those of *Paradacerla* than between species of *Paradacerla*. It may therefore be considered that only a single genus is represented. Studies on the genitalia in the Miridae (Kullenberg, 1947; Slater, 1950; Kelton, in press) have suggested that these structures have more reliable characters than the external appearance on which to base generic limits and relationships of species. However, other species of the Herdoniini must be studied before the value of such characters as brachyptery, projections on the pronotum and the scutellum, pubescence, and other external features used in separating genera is more fully known.

Key to species of *Paradacerla*

1. Posterior margins of hemelytra white; species very hairy 2
   Posterior margins of hemelytra concolorous; species with only short pubescence 3
2. Second antennal segment linear ..... *P. azteca* Carv. and Using.
   Second antennal segment conspicuously enlarged before apex ..... *P. hirsuta* n. sp.
3. Pronotum dark brown, posterior margin partly white ..... *P. downesi* (Kngt.)
   Pronotum and posterior margin concolorous ..... *P. formicina* (Parsh.)

Paradacerla formicina (Parshley, 1921)

Figs. 2, 6, 9, 11

Distinguished by concolorous hind margin of pronotum; first antennal segment usually longer than width of vertex of head; incrassate second antennal segment; short and sparse pubescence; and genital structures.

Male genitalia.—Left clasper sharply curved; sensory lobe moderate in size, rounded, with numerous long bristles; shaft uniformly slender, the serrations on outer margin pronounced; apical process very short. Right clasper relatively slender; apical process horizontal, beaklike.

Vesica distinctive, but similar in general appearance to that of *Dacerla mediospinosa;* membranous except for moderately sclerotized area on large process; apices of sclerotized area, membranous process, and middle of small process spined; ductus seminis rather broad, slightly constricted at middle.

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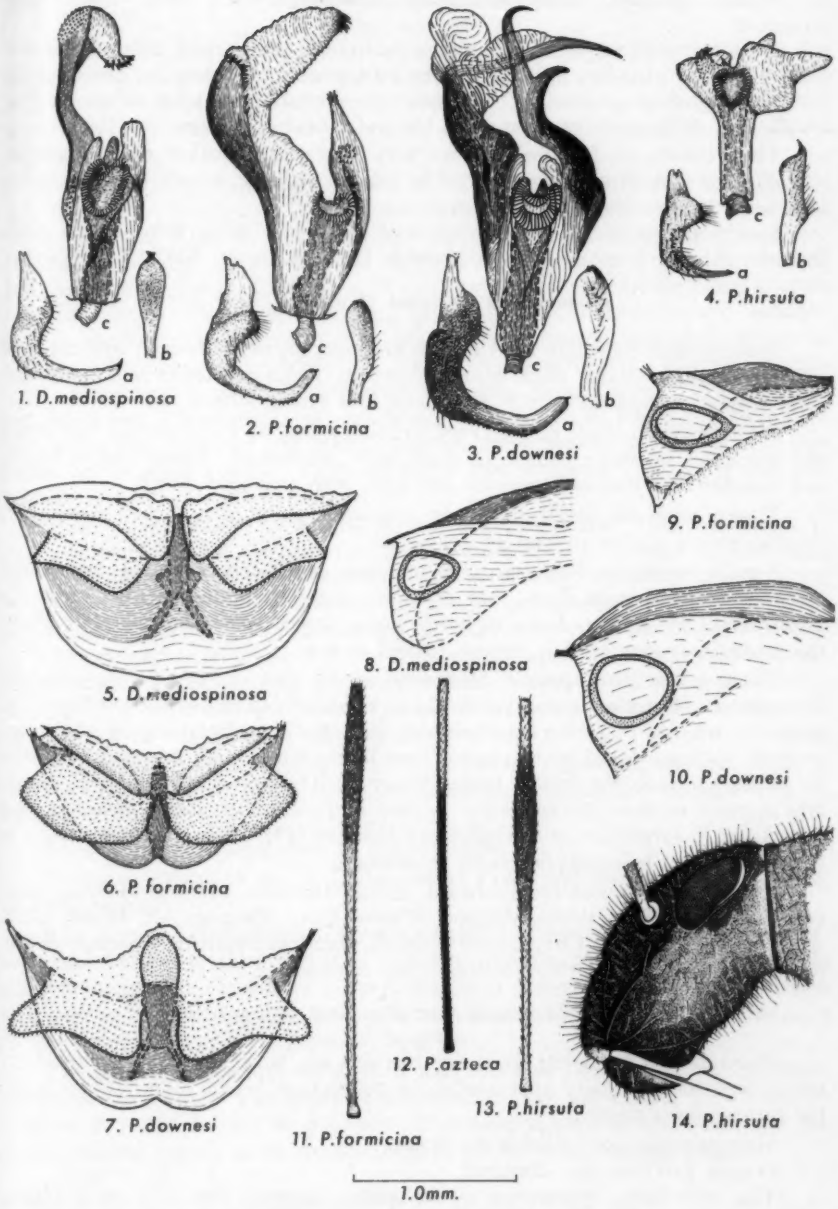

Figs. 1-14. *Dacerla* sp. and *Paradacerla* spp. 1-4, Male genitalia. 5-7, Posterior walls of female genitalia. 8-10, Sclerotized rings of female genitalia. 11-13, Second antennal segment. 14, Head.

a, Left clasper, dorsolateral view; b, right clasper, lateral view; c, vesica, dorsal view; posterior walls, anterior view; sclerotized rings, dorsal view.

Female genitalia.—Sclerotized rings relatively small, oval, and widely separated.

Posterior wall of bursa copulatrix with the inter-ramal lobes large and spinose, united mesially; folds above the inter-ramal lobes narrow, reaching the prominent median process. These folds are probably homologous to the "H structures" of Slater (1950), and the "lateral lobes" of Kelton (1955).

The genitalia of *P. formicina* are very similar to those of *Dacerla mediospinosa*, and indeed the resemblance is just as striking as are the differences between *P. formicina* and *P. downesi*.

Specimens examined from:—British Columbia: Goldstream, Royal Oak, Saanich district, Victoria. Other records from: Oregon, California, Idaho.

Paradacerla downesi (Knight, 1927)

Figs. 3, 7, 10

Distinguished by white markings on hind margin of pronotum; first antennal segment usually shorter than width of vertex; incrassate second antennal segment; sparse pubescence as in *P. formicina;* and genital structures.

Male genitalia:—Left clasper very similar to that of *P. formicina,* but larger and serrations on outer margin of shaft more numerous. Right clasper longer and broader than that of *formicina,* the apex with a shallow notch.

Vesica with the processes partly sclerotized, and each forked near apex; ductus seminis similar to that of *formicina.*

Female genitalia:—Posterior wall of bursa copulatrix with the inter-ramal lobes large and spinose as in *formicina* but of different shape; folds above the inter-ramal lobes absent; dorsal structure dome-shaped and spinose directly above the median process; median process forked at base.

There are reliable specific differences in the genitalia of *P. formicina* and *P. downesi.* The vesicae are similar to the vesica of *Dacerla mediospinosa.* The posterior wall of *P. formicina* resembles that of *D. mediospinosa* in the membranous foldings dorsal to the inter-ramal lobes, whereas *P. downesi* resembles *D. mediospinosa* in the forked medial process. The posterior wall of *P. formicina* appears to show no similarity to that of *P. downesi.* The posterior wall shown for *P. formicina* by Carvalho and Usinger (1957, Fig. 17) is probably an error, the figure being applicable to *P. downesi.*

Specimens examined from:—Idaho: Athol, Harvard, McCall, Melrose, Moscow Mt., Nez Perce, Waha, Weippe, Willow Flat. Oregon: Mt. Hood. Utah: Allen Canyon, Garden City, Logan Canyon, Mendon, Murray, Syracuse. Washington: Mt. Adams. Other records from: Montana.

Paradacerla azteca Carvalho and Usinger, 1957

Fig. 12

Distinguished by white posterior margins on hemelytra; linear second antennal segment; and hairy appearance, the pubescence white, long, and erect and the shorter hairs slanted.

Male genitalia not available for study.

Female genitalia not dissected.

The very hairy appearance of the species suggests that it is more closely related to *P. hirsuta* n. sp. than to *P. formicina* or *P. downesi.* It is readily separated from *P. hirsuta* by the linear second antennal segment.

Specimens examined from:—Mexico: Allotype, 26 mi. W. Guadalajara, Nov. 22, 1948, H. B. Leech; Pamillas, Queretaro, Sept. 30, 1958, H. F. Howden; and 9 mi. N. San Luis de la Paz, Guanajuato, Oct. 1, 1958, H. F. Howden.

***Paradacerla hirsuta* n. sp.**

Figs. 4, 13, 14

Distinguished by white posterior margins on hemelytra; conspicuously enlarged subapical portion of second antennal segment; and hairy appearance as in *P. azteca*, with erect hairs on head, thorax, and abdomen pale, long, and interspersed with shorter, recumbent hairs, but dorsum of abdomen with long, dense, appressed golden pubescence.

Female:—Length, 5.6 mm. Head: width, 1.22 mm.; vertex, 0.7 mm.; length, 1.22 mm.; front black, side of head reddish-brown. Antenna: I, 0.73 mm. long, black with pale base; II, 2.31 mm., pale yellowish with enlarged region black; III and IV missing. Antennal fossa separated from eye by a distance less than half diameter of fossa. Rostrum 2.24 mm. long, reaching middle coxa; buccula very prominent. Pronotum 1.22 mm. long; 0.98 mm. wide at middle; reddish-brown, the collar and basal margin black; lateral margin rounded, widest at middle; callus obscured. Scutellum convex, reddish-brown. Hemelytra very short, extending to second abdominal segment; reddish-brown, the posterior margins white. Abdomen 2.38 mm. wide; dark-brown to black, the margin of first abdominal segment, and middle area of third, fourth, fifth and sixth segments below light yellow. Legs reddish-brown to black. Genitalia not dissected.

Male:—Very similar to female in size and coloration. Head: width, 1.22 mm.; vertex, 0.66 mm.; length, 1.22 mm. Antenna: I, 0.73 mm.; II, 2.45 mm.; III, 1.54 mm.; IV, missing. Rostrum 2.24 mm. long, reaching middle coxa; buccula very prominent. Genitalia: left clasper much smaller than those of *D. mediospinosa* and other *Paradacerla* spp. studied; sharply curved; sensory lobe as in *P. formicina;* serrations on shaft very prominent; apex with a pronounced beak. Right clasper slender, apical process vertical. Vesica small and considerably modified in comparison with other species of the genus; membranous, one lobe spinose; ductus seminis as in other species studied.

Holotype:—Female, Taxco, 4 mi. S., 4,800 ft., Guerrero, Mexico; Aug. 8, 1954; J. G. Chillcott. No. 6789 in the Canadian National Collection of Insects, Ottawa.

Allotype:—Male, same data as for holotype.

Paratype:—Male, 13 mi. N. Chilpancingo, Guerrero, Mexico; Aug. 26, 1958; H. F. Howden.

The species differs from *P. formicina* and *P. downesi* in the hairy appearance, the very prominent buccula, and the position of the antennal fossa in relation to the eye. It differs from *P. azteca* in the enlarged subapical portion of the second antennal segment; the golden recumbent pubescence on the dorsum of the abdomen; and the prominent buccula.

The genitalia, although reduced in size, resemble those of *D. mediospinosa* and *Paradacerla* spp. The spines or serrations on the left clasper are similar to those of *P. formicina* and *P. downesi*. The basic pattern of the vesica and the ductus seminis appear to be similar to those of the other species studied.

Summary

Myrmecomorphic species of *Paradacerla* Carvalho and Usinger, 1957, differ from *Dacerla mediospinosa* Signoret, 1881, mainly in not having a pronotal spine. The genitalia suggest that the two genera are very closely related. A key to species of *Paradacerla* is given, and a new species from Mexico, *P. hirsuta*, is described. *P. formicina* and *P. downesi* are known from the western United

States, the former also occurring in British Columbia. *P. azteca* is known from Mexico.

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Book Review

MONOGRAPHIC STUDY OF THE GENUS *NOMADOPSIS* ASHMEAD (HYMENOPTERA: ANDRENIDAE) by Jerome G. Rozen, Jr., 202 pp. 18 plates. 17 maps. Univ. Calif. Pubs. Ent. 15. 1958.

In this monograph are reviewed the nearctic species of *Nomadopsis*, found in the xeric parts of western North America. The genus is divided into three, one of the three new subgenera being identified only through the males. Thirty-three species are recognized, nine as new, as well as three new subspecies. One species name is a possible synonym. Two Ontario names, *Calliopsis interrupta* Prov. and *C. quadrilineata* Prov., are excluded, likely belonging elsewhere, although listed in *Nomadopsis* by Michener in the Muesebeck catalogue. Some new synonymy is also recorded.

Most taxonomists will envy the wealth of data available for this study. Thirty-two of the species are described from both sexes, some from the mature larvae also. Extensive biological discussion is presented, particularly upon flower-visiting, mating, nesting and parasitism. Keys to the adults are given. The description for each species is accompanied by line figures and by a distributional map. Nomenclatorial purists will shiver at the name *bobbae* being proposed 'in honour of my wife Barbara'. Too, they would have preferred to have seen the derivation of the new name *xenus*, being in combination with a feminine generic name; presumably it is to be considered as a noun suggesting a stranger and thereby a somewhat discordant element in the genus. Michener's example is followed in considering the name *anthidius* as such; although there seems to be no firm derivation, yet surely it should be assumed to mean *Anthidium*-like and treated as an adjective. However, these are niggling points in a remarkably complete monograph of very considerable merit.

O. Peck

Note on Destruction of Grasshopper Eggs by the Field Cricket *Acheta assimilis luctuosus* (Serville) (Orthoptera: Gryllidae)[1]

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Routine grasshopper egg surveys in southern Alberta from 1954 to 1957 revealed unexpectedly small numbers of egg pods in certain locations that were regarded as favoured oviposition sites for *Melanoplus bivittatus* (Say). These locations were graded roadsides with a bare or sparsely covered slope on the field side of the ditch. The bottom of the ditch and the other slope up to the roadway were usually covered with a moderate to heavy growth of weeds and grass. In these years the grasshoppers hatched late, the nymphs developed slowly, and the adults did not mature until September. As oviposition took place in cool fall weather, it was restricted mainly to the bare ditchbanks facing south or west, which provided sheltered spots warmed by insolation. Sampling in these spots revealed fewer egg pods than should have been produced by the number of *M. bivittatus* found in the preceding adult survey.

Along the ditchbanks there were many small holes the size of an egg pod but containing no traces of eggs or pods. Both birds and mice dig egg pods out of the soil, but they leave characteristic marks and these were not evident here. The presence of numerous crickets along the ditches both on the soil surface and sheltering in the holes suggested that they might be predators. They were not at any time seen feeding on eggs, but this is perhaps not surprising as they are mostly nocturnal feeders (Gangwere, 1958). There are suggestions in the literature, based only on conjecture, that crickets may destroy grasshopper eggs, but the only report substantiated by observation that was found was that by Criddle (1925). He stated that the field cricket eats a few eggs from each pod leaving the remainder exposed.

Crickets were collected from these localities and killed in alcohol, and their gut contents were examined under a microscope. Of 22 specimens examined, five had empty crops and so had not fed recently. Eleven of the remaining 17 had fragments of grasshopper egg chorion in the crop. The fragments of chorion were easily recognizable and were always plentiful when present.

Evidently the holes in the ditchbanks had contained egg pods and these had been completely consumed by crickets. Usually crickets do not dig in the ground for their food, but we can assume that soil-blowing exposed the froth plug in the neck of the pod to which the insects were attracted. Rough estimates from the number of pods found and the number of holes observed indicated that destruction was as high as 50 per cent in some of these localities. Since there are often large numbers of crickets along the roadsides in the fall, they may be more important as predators than is generally assumed.

The crickets were identified as *Acheta assimilis luctuosus* Serville by A. R. Brooks, Canada Department of Agriculture Research Laboratory, Saskatoon, Saskatchewan.

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Scambus pterophori (Ashm.) (Hymenoptera: Ichneumonidae), a New Parasite of the European Corn Borer, *Pyrausta nubilalis* (Hbn.) (Lepidoptera: Pyralidae), in Canada[1]

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In late August, 1957, a parasitized second-generation pupa of *Pyrausta nubilalis* (Hbn.) was observed in silks of an immature corn ear in the experimental plots at St. Jean. The pupa was incubated at 75°F. in a petri dish, and two weeks later an ichneumonid parasite emerged and was identified by Mr. G. S. Walley, Entomology Division, Ottawa, as *Scambus pterophori* (Ashm.). A second generation of *P. nubilalis* is very unusual in the St. Jean area. This is apparently the first record of this ichneumonid as a parasite of *P. nubilalis* in Canada.

The distribution of this ichneumonid is transcontinental in Canada (Muesebeck, 1951, p. 187). Goidanich (1931) stated that it had been recorded only from North America. Vinal and Caffrey (1919, p. 58) reported it from Massachusetts as a parasite of the pupa of the European corn borer. Chu and Hsia (1937) mentioned only America and the Philippine Islands in records of its distribution.

Caffrey (1919, p. 22) stated that the ichneumonid larvae feed within the body of the borer and complete their growth after the latter has reached the pupal stage; the parasite pupates within the pupa of its host and later emerges. Baker *et al.* (1949, p. 179) reported that it parasitizes the second generation of the European corn borer in Massachusetts and is collected more often from borers associated with weeds than from those found in corn. Wilder (1927) mentioned that it is a parasite of various stem-boring and stem-gall-making Lepidoptera and Coleoptera, including the European corn borer, and tried unsuccessfully to maintain the adults in breeding cages with different types of food; no mating or feeding was observed and the adults lived only a few days.

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